VIRTUAL INTERFACE FOR CONTROLLING A REMOTE-HANDLE ROVER

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Abstract

This paper describes a standard point-to-point remote control system devoted to control low-mass rovers equipped with handle robotic arms that carries sensors on board working in hard environments such as mines, gas pipes or space missions. The main objective of this system is to provide the capability of transporting data as much as controlling a remote vehicle through a virtual interface.

The communication system being developed takes care of different layers involved into the communication process providing services to support the upper layers as the OSI model does from the physical to application layers.

This wireless communication is thought to control a rover called VANTER (Spanish acronymous of «Non Crewed Autonomous Vehicle Specialized in Recognition»). It is a prototype being developed by the authors of this work and it is aimed for working in automatized and guided mode.

The rover is equipped with a six free-degrees robotic arm that can be handled through a joystick thanks to images from a camera. The robotic arm is also equipped with a forceps able to pick up little solid & liquid samples from the ground. VANTER carries a set of wheels, each one with a mechanic and independent shock-absorber. Its low mass and little size makes it ideal for using in hard environments where humans can not.

Keywords
Point-to-point control, wideband radiolink, UHF modems, communication protocol, remote control, telemetry, telecommand, handle rover, robotic arm, user applications, virtual interface.

1. INTRODUCTION.

In the last years is usual to see the same protocols in different radio frequencies, so a standardization of the communication systems is the most important effort. This is the main objective of the Consultative Committee for Space Data Systems where the world's major space agencies discuss in an international forum about to develop hardware and software products using the same standards techniques [2]. The implementation of standard protocols promotes understanding of exchanged data between different missions as the case of the orbiter Mars Express from ESA and rovers Opportunity & Spirit from NASA. Besides last space missions since Mars Pathfinder (1996) use commercial devices with little variations applied to the space requirements like UHF modems [7]. The choice of alternative wavelengths must solve the problems associated to the power consumption, cover distance or more directive antennas, so radiomodems based on UHF band are being developed.

In the automation and control areas there are previous experiments for controlling rovers through a workstation developed under a graphical user interface where 3D scenes are generated for tracing routes [1].

This issue describes a standard point-to-point remote control system devoted to control low-mass rovers equipped with a handle robotic arm that carries sensors on board working in hard environments such as mines, gas pipes or space missions.

Authors of this project introduce several new developments so the main objective of this system is to provide the capability of transporting telecommand and telemetry data over the same channel frequency as much as controlling a remote bot and its six-free degrees robotic arm through a virtual user interface [6] (see fig.1).

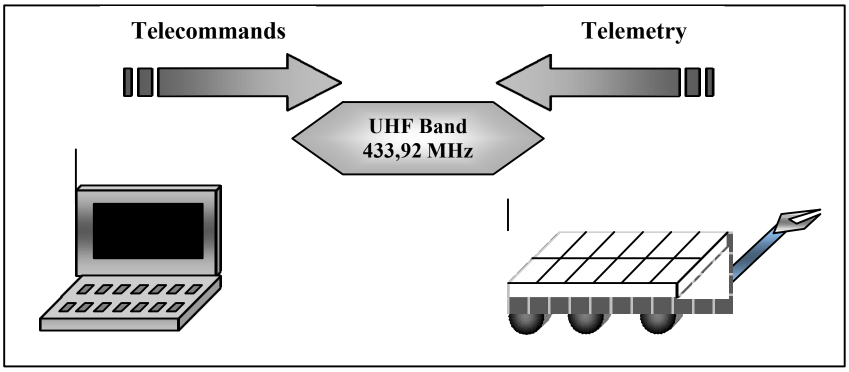

Figure 1. Wireless control system between a user application and a remote-handle rover

The paper is divided in several sections describing firstly the layers model and the communication protocol designed for allowing a standard use with different science or engineering applications where a sample of the control panel on the application layer is screened. The wireless communication is thought to control a rover called VANTER explained in the following subsection where rover's features are described and pictures from the robotic arm are shown. Finally the authors will consider targets to get in an early future.

2. LAYERS MODEL.

The system being developed takes care of different layers involved into the communication process providing services to support the upper layers as the Open Systems Interconnection (OSI) model does from the physical to the application layers. In this communication system only the network, transport, session and application layers have to be developed by the authors and the presentation layer does not apply (see fig.2).

The physical layer makes use of a RF modem that provides a wideband radiolink by means of the correct universal asynchronous receiver/transmitter (UART) set up at maximum baud rate speed of 115,2 Kbps with an operating frequency set up to 433,92 MHz, FSK modulation and carrier detection.

The UHF modem chosen for this communication link is motivated by three factors [4]: use omni to omni low-gain antennas requiring no pointing [3], reduce free-space losses compared to higher frequencies in other bands [e.g S-band] and provide a standard communication system able to interoperate with current and future missions applied to different engineerings [5,8].

The link layer carries the network data units free of errors from origin to destination. Frames are divided in smaller units with packets not bigger than 96 bytes and numbered so bits transmitted are assured thanks to a data error control protocol implemented into the modem.

The network layer is thought and designed in a different concept from OSI 7-layers model according to ID numbers instead of IP addresses. If the source side corresponds to the local user it has the same handle number; if the destination side correspond to the remote rover it has so many handles as sensors or devices to control (see subsection 2.1 for further information).

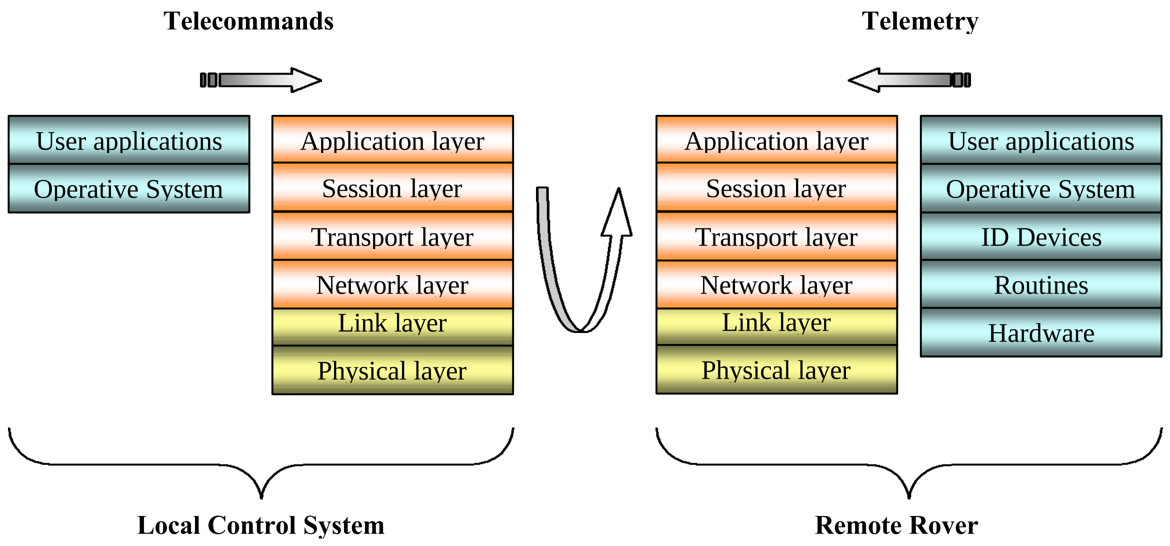

Figure 2. Communication layer model

The wireless modem has a communication able to transfer data in half-duplex way. This transfer way is a connection-devoted protocol and it has to be managed by the transport layer. Moreover this layer has to provide a communication free of errors between the local and remote applications.

Both source and destination can initiate the data transmission and transfer different kind of information (like telecommand and telemetry data) over the same channel at the same time. The great priority of the session layer is to establish a robust protocol based in a beacon signal that allows to start the transmission whenever be over the cover range avoiding delayed times.

The application layer is developed with a graphical programming tool under windows environment. This programming tool allows to make virtual instruments like a control panel with numeric and Boolean controls. The front panel is divided in two main labels, the first one allows to control the rover's movements by means of a joystick and the second one has knobs and digital bars for controlling the handle robotic arm with accuracy (see fig. 3). It is possible to use a set of commands supporting the controls described and once they are selected make up the full message to be sent.

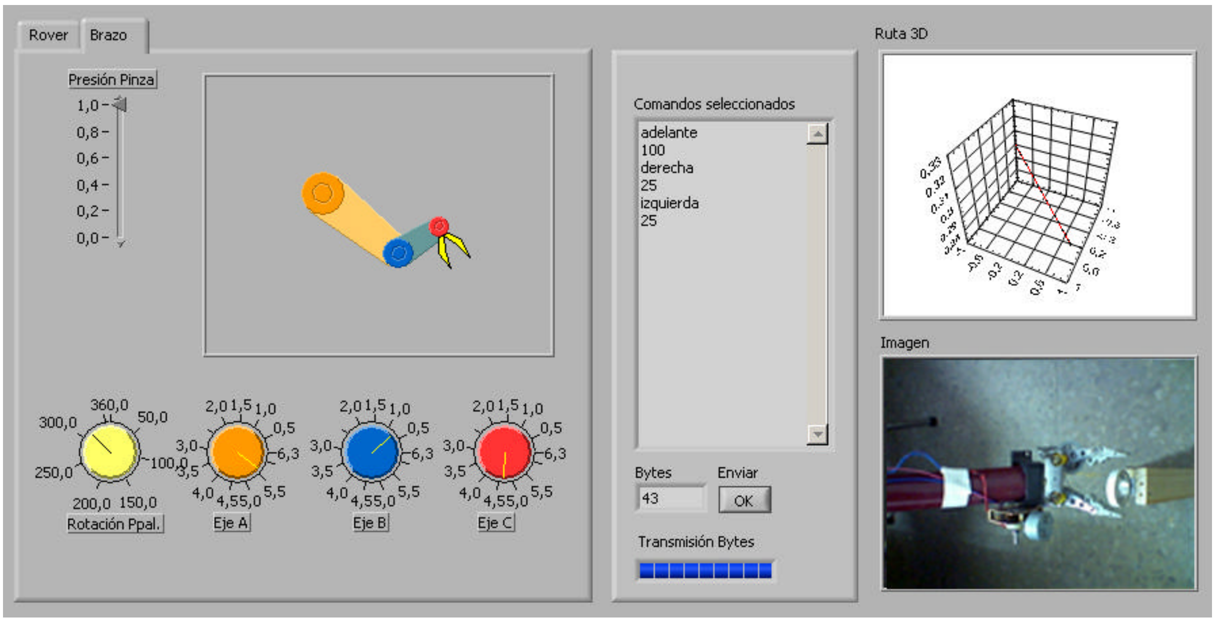

Figure 3. Sample of the control panel on the application layer

This panel shows in real time sensor status, communication errors and well-done actions. For so it is possible to monitorize and manage information uploaded and downloaded to the remote point.

In telecommand mode this system allows to control the rover in real time directly through commands or synchronizing works through uploaded commands sequences. These works include a great variety of actions because the controlling software is designed like an open device system. In telemetry mode the local computer can receive data with scientific information as images from cameras, log actions or sensors status.

2.1 Low Mass Rover.

VANTER, Spanish acronymous of «Non Crewed Autonomous Vehicle Specialized in Recognition» is a prototype rover being developed by the authors of this work and it is aimed for working in automatized and guided mode.

The rover is equipped with a six free-degrees robotic arm (see fig. 4) that can be handled through a joystick by means of images from a camera. The robotic arm is also equipped with a forceps able to pick up little solid & liquid samples from the ground. VANTER carries a set of wheels, each one with a mechanic and independent shock-absorber. Its low mass (no more than 12 Kg) and little size (35 x 75 x 30 cm) makes it ideal for using in hard environments where humans can not.

The camera is thought to carry a filter wheel with a fish-eye lens and can take panoramic images at 1 meter over the land when its arm is placed looking up. These panoramic images can be used for tracing routes over the ground and guide the rover automatically.

The user application layer provides a high-level language and it allows to control multimedia functions directly (e.g. from the camera) or the rover's hardware on board indirectly, in this way every device that belongs to the rover has an ID number and a command list for driving and managing (e.g. handle arm, wheels movements, etc). Even a commands set is available for doing complex works in a single way.

The user application rests on the computer operative system and manages a directory tree hierarchy. Thanks to the data transfer protocol is possible to upload files from the local computer to the remote rover for setting up the operative system, reconfiguring software or including new working routines.

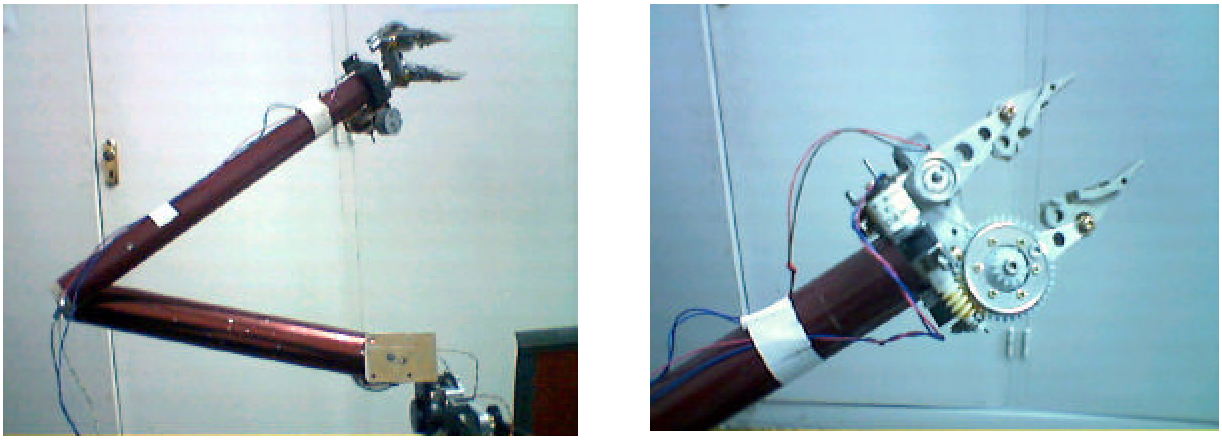

Figure 4. Robotic arm from rover VANTER

Due to a rugged motherboard [9] included into the rover is possible to control indirectly the hardware on board by means of an I2C communication between the mainboard's processor and the microcontroller that drives the low-level hardware (i.e. encoders, dc motors, etc). Further features are IDE & PCI slots, parallel port connector, serial & USB 2.0 connectors, VGA port, RJ-45 LAN port, I2C pin-header, cardbus & compact flash slots, processor at 600 MHz with power consumption up to 15 Watts and maximum size of 17x17 cm.

3. CONCLUSIONS.

This paper shows a standard point-to-point communication protocol between a user application and a remote rover by means of a radiolink. So an advantage is its use in hard environments where human presence is not possible. Users have a powerful tool that includes an easy-to-use virtual interface for controlling a remote handle arm with six free-degrees, a little autonomous vehicle and a camera that allows monitoring the actions done.

The packets' RF transmission time is given by T = 3,6 ms + (NumByte +2) x 0,156 ms so an image file at 640 x 480 of resolution without compression (300Kb) will be transmitted at maximum speed with a transmission time around 60 s (despise header and CRC fields). The same image with compression (typically 20Kb) will be transmitted in 4 s.

As described above to monitorize the remote rover by means of images from a camera is necessary to increase the baud rate if a real time control is required.

Other research lines are actually being explored and the use of alternative frequencies (e.g. S-Band) are considered. Higher frequencies than UHF-Band expect to have higher widebands but require an accuracy pointing control to reduce signal losses.

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