Tecnologías para búsqueda y rescate de personas

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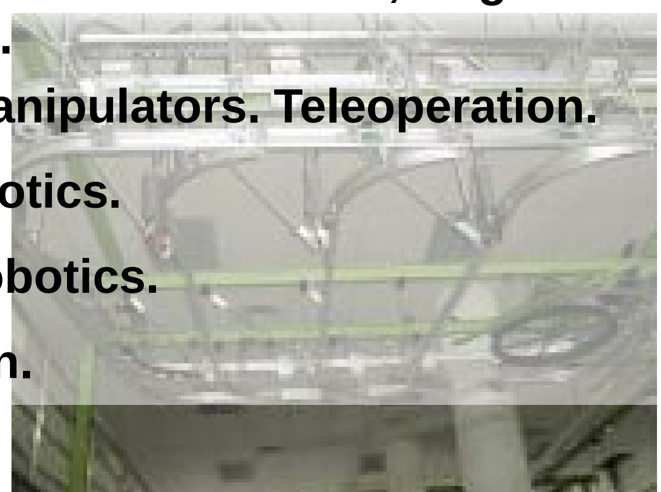
Departamento de Ingeniería de Sistemas y Automática

THE DEPARTMENT OF "INGENIERIA DE SISTEMAS Y AUTOMATICA"

The Staff of the Department has 25 members: 17 doctors and 8 engineers.

Coordinator of Master and PhD Studies "Ingeniería Mecatrónica":

Research Areas:



1. **Non-linear control systems.**
2. **Intelligent control systems: fuzzy logic, neural networks, genetic algorithms.**
3. **Robotic manipulators. Teleoperation.**
4. **Mobile robotics.**
5. **Surgical robotics.**
6. **Automation.**

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Investigación en Robótica de Exploración, Búsqueda y Rescate.

Motivaciones:

- Éticas
- Técnicas
- Científicas
- Económicas

Dificultades:

- Tecnología de frontera
- Uso dual
- Rentabilidad

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Tecnologias para la Búsqueda y Rescate.

Sistemas robóticos:

Robots móviles y Manipuladores Móviles::

- Terrestres o UGV´s (Unmanned Ground Vehicles)
- Aéreos o UAV´s (Unmanned Aerial Vehicles)
- Marinos o UMV´s (Unmanned Marine Vehicles)

(ROV, Remotely operated vehicle; USV, unmmaned surface vehicle,…)

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…Tecnologias para la Búsqueda y Rescate (Cont.)

Sistemas sensoriales y de percepción:

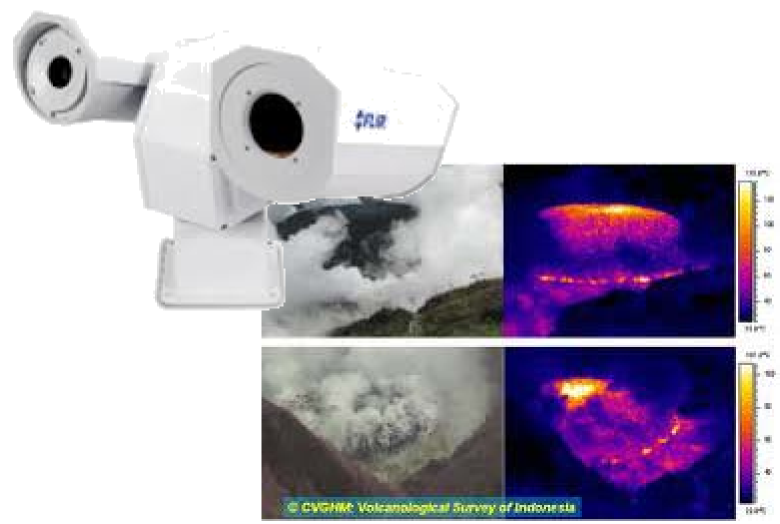
Sistemas para localización (GPS, LIDAR Laser Imaging Detection and Ranging, Cámaras CCD, FLIR Forward Looking InfraRed),

Sistemas para manipulación (Sistemas táctiles, de presencia, …)

Sensores para monitorización ambiental (Gases, Temperatura, Presión, Lluvia, Viento Radiación, Luminosidad …)

Monitorización de entornos estructurados (De rotura ,de vibración, de choque, de esfuerzos, de desplazamiento, de nivel de liquidos,

Sensores biomedicos (temperatura, Sistema cardiaco, respiratorio, neuronal, ,…)



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…Tecnologias para la Búsqueda y Rescate (Cont).

Sistemas de comunicación:

- Tecnologías inalambricas: (WIFI, WIFI larga distancia, ZIGBEE, WIMAX, GPRS, 3G, 4G…)
- Redes INALAMBRICAS de SENSORES (WSN, Wireless Sensor Networks)

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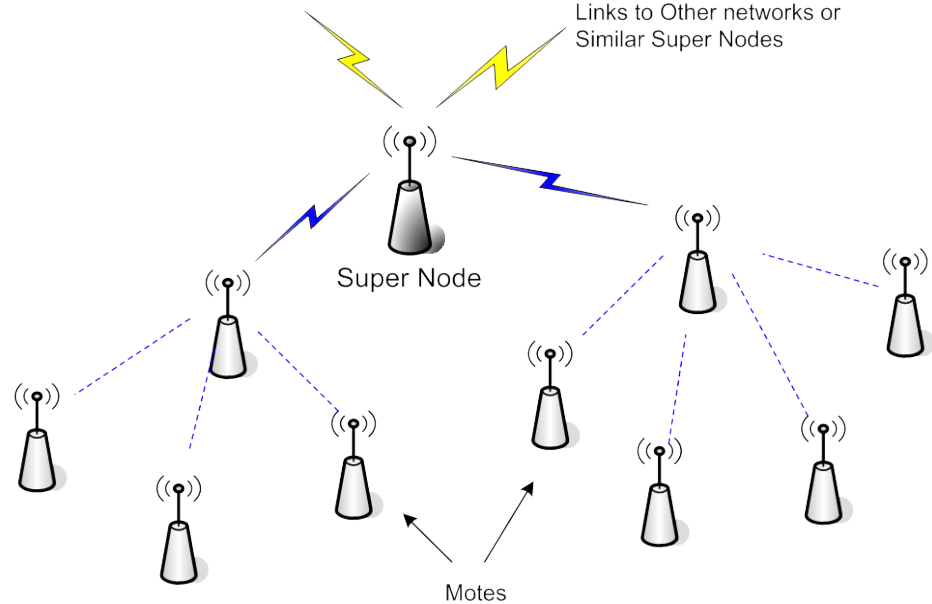
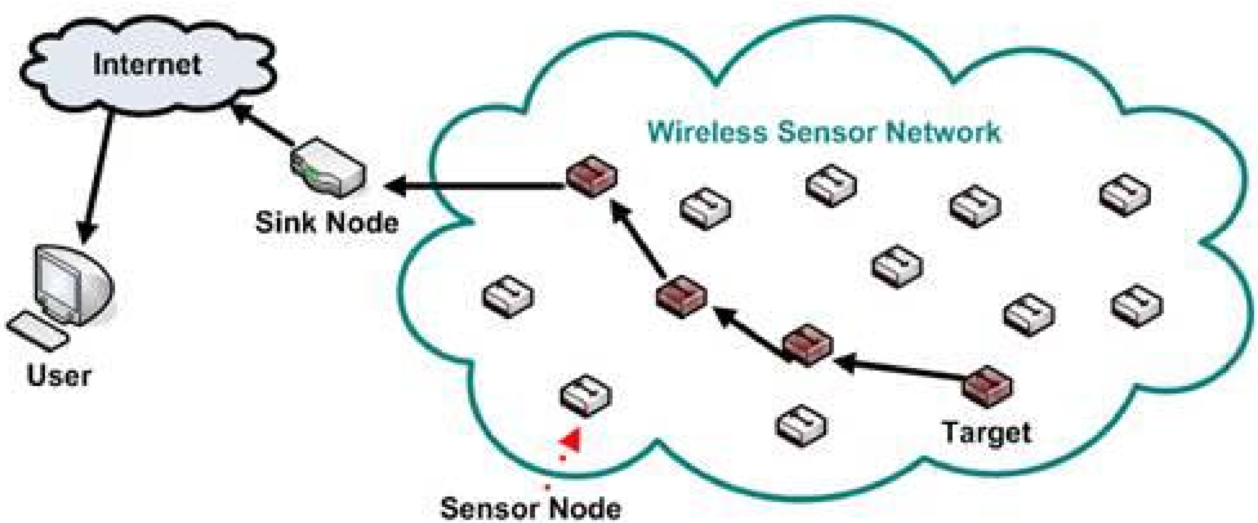
REDES INALAMBRICAS de SENSORES





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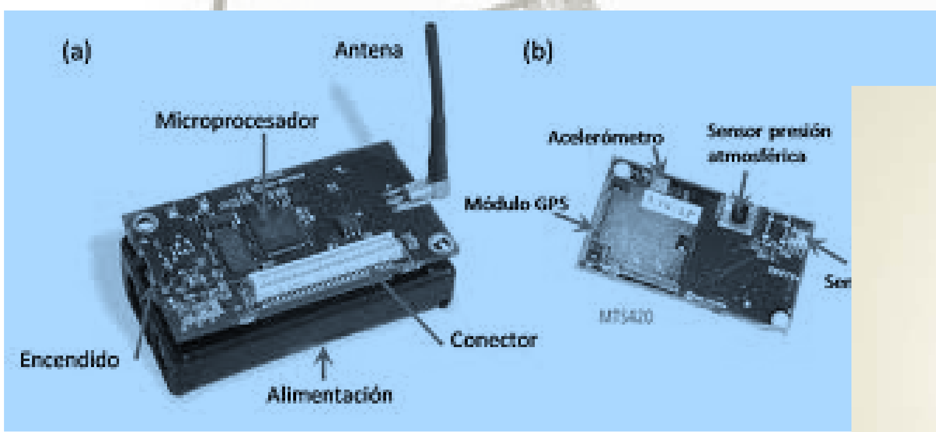
…REDES INALAMBRICAS de SENSORES (Cont…)

- Smart Cities.
- Agricultura.
- Monitorizacion Ambiental.
- Estaciones Meteorologicas.
- Biomedicina.
- ….



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The origins:

- RAM 1 (Ollero, 1991).
- AURORA (Ollero, 1993-1996).

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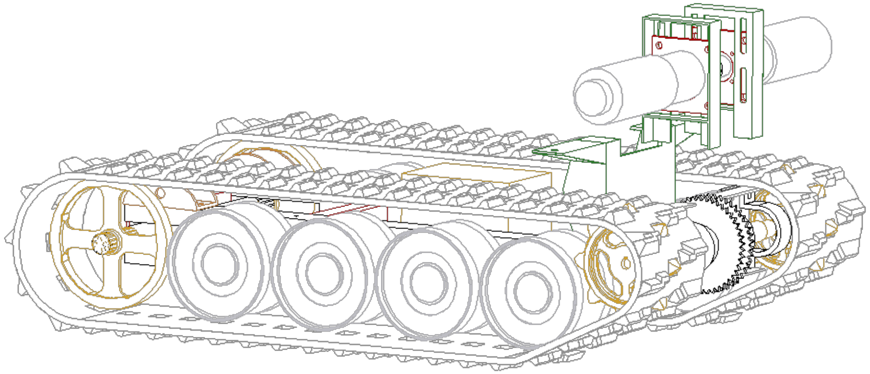
SEARCH AND RESCUE ROBOTS
AURIGA-I (García-Cerezo, 1998)



THE AURIGA I MOBILE ROBOT

General characteristics:

Dimensions: 0.75 m width, 1.35 m length, 0.84 m height.

260 kg tracked vehicle for outdoor navigation.

Powered by an on-board petrol-fed ac-generator of 4 kW.

Locomotion system is based on the skid-steering principle.

Top speed: 1 m/s in straight line movement.

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SEARCH AND RESCUE ROBOTS
AURIGA-IR (García-Cerezo, 2003)

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SEARCH AND RESCUE ROBOTS
AURIGA-I I (García-Cerezo, 2003)

THE AURIGA II MOBILE ROBOT

General characteristics:

Dimensions: 0.7 m width, 1.2 m length, 0.96 height.

190 kg tracked vehicle for outdoor navigation.

2 DOF self-stabilized landing platform

Powered by an on-board petrol-fed ac-generator of 4 kW.

Locomotion system based on the skid-steering principle.

Top speed: 0.8 m/s in straight line movement.

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Some of our mobile robots

CUADRIGA-I

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Some of our mobile robots

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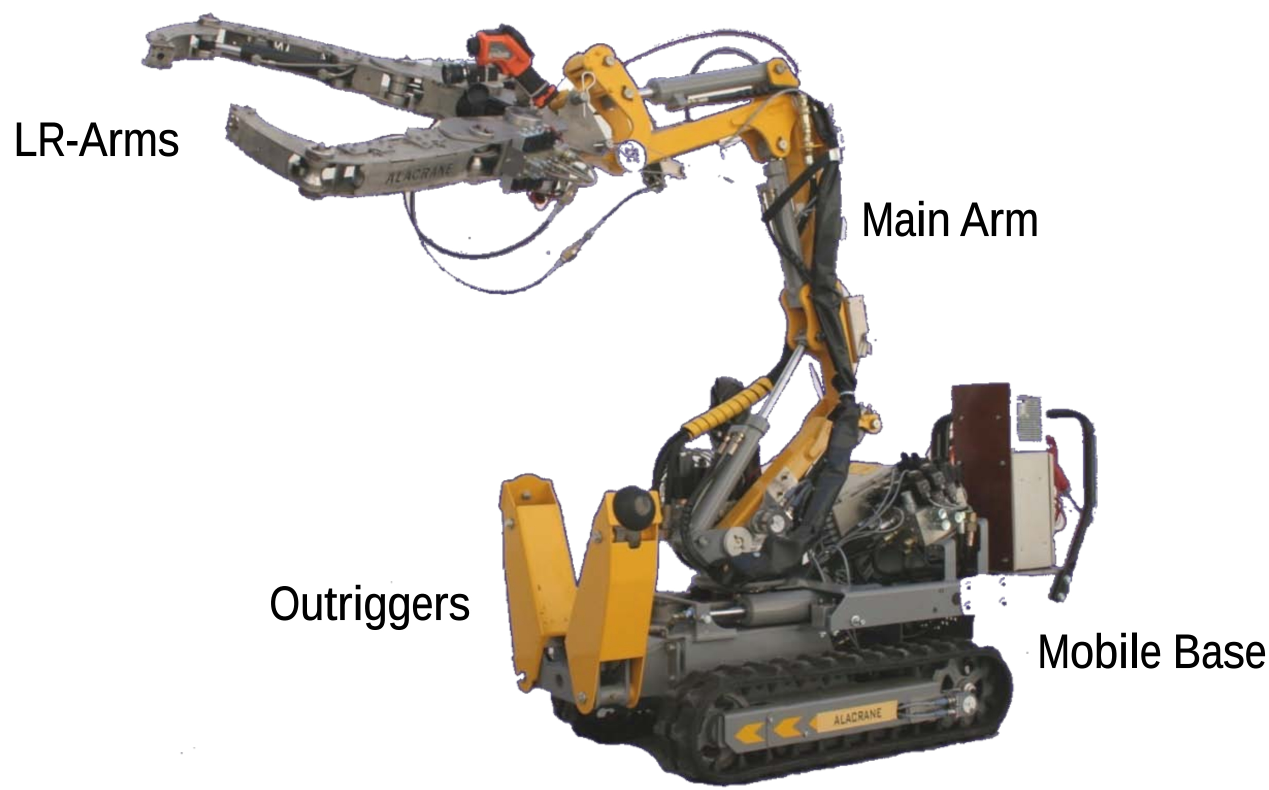
SEARCH AND RESCUE ROBOTS
ALACRANE I (García-Cerezo, 1999)

The Mechatronic System

A. The ALACRANE robot is a fully hydraulic robot that has been developed from a modified small demolition machine by Brokk®.

The robot consists of three main parts: the mobile base, the main arm, and the LR-Arms dual manipulator.



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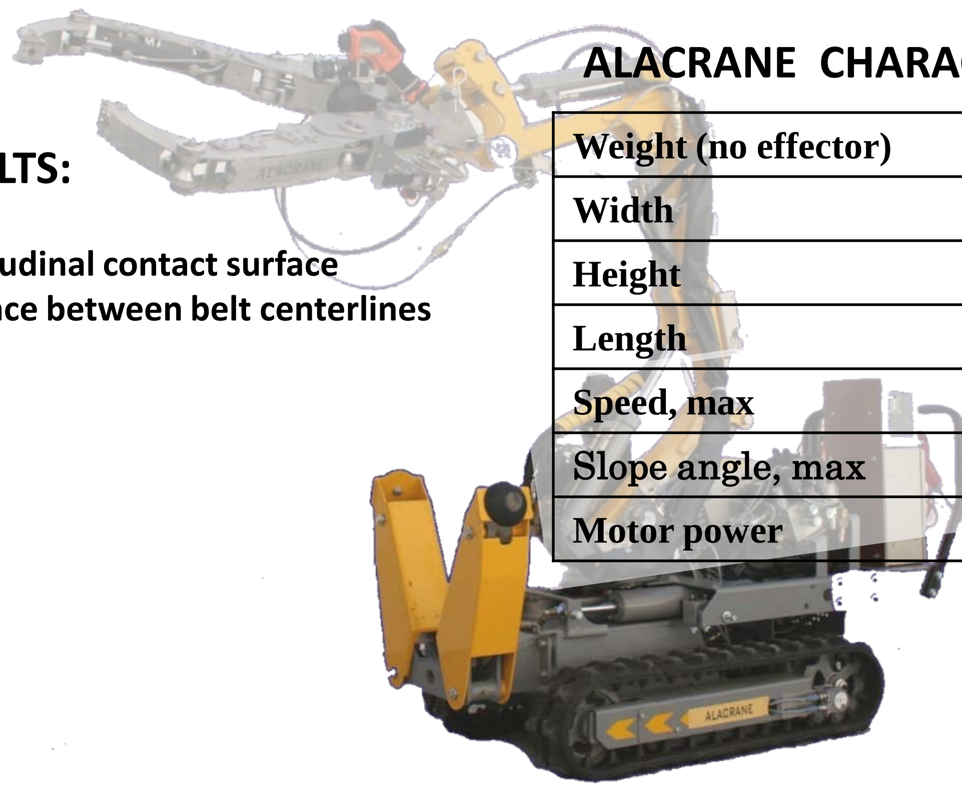
II. The Mechatronic System of Alacrane (cont…)

A. *Mechanical Design.*

1)The Mobile Base: **Its goal of the mobile base is to provide traction on rough terrain, such as rubble and moderate slopes. Tracked skid-steer traction is controlled by the speeds of two independent hydraulic motors (*VL* and *VR*) with encoders for dead-reckoning**

RUBBER BELTS:
130mm: wide,
735mm: longitudinal contact surface
470mm: distance between belt centerlines



ALACRANE CHARACTERISTICS

Weight (no effector)	380 kg
Width	600 mm
Height	940 mm
Length	1200 mm
Speed, max	1.5 km/h
Slope angle, max	30º
Motor power	4 kW

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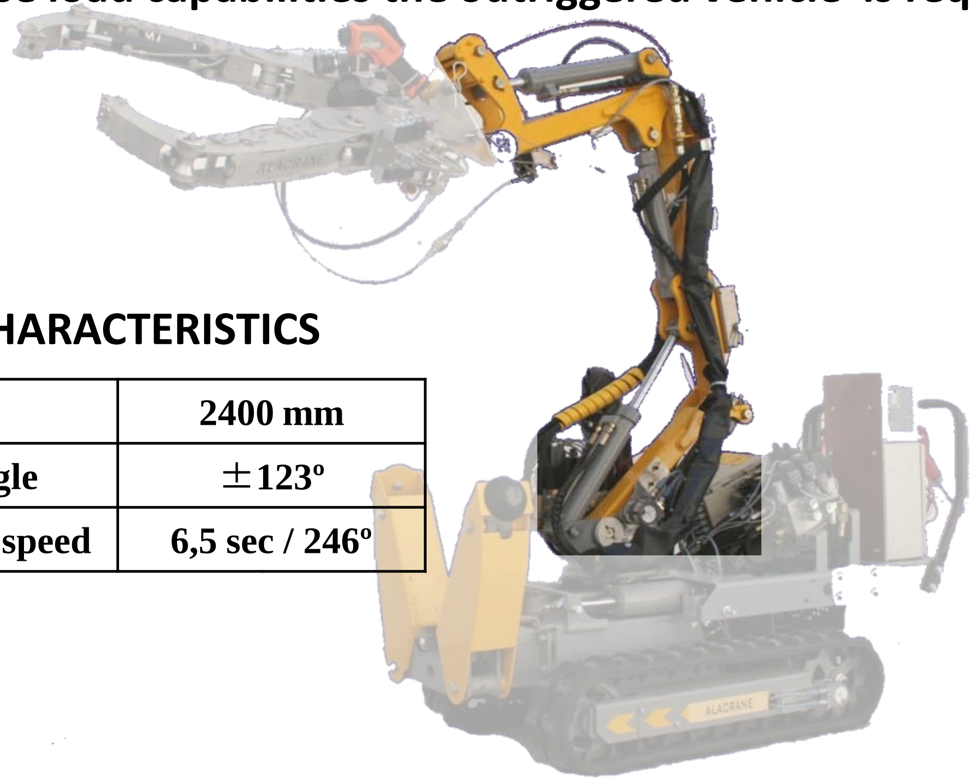
II. The Mechatronic System of Alacrane (cont…)

A. *Mechanical Design.*

2) The Main Arm:

4 DOF with 5 hydraulic cylinders (joints q_1 to q_5).
Payload: 120kg fully extended,
450kg in the vicinity of the arm base.
For these load capabilities the outriggered vehicle is required.



ARM CHARACTERISTICS

Range	**2400 mm**
Base angle	**±123º**
Slewing speed	**6,5 sec / 246º**

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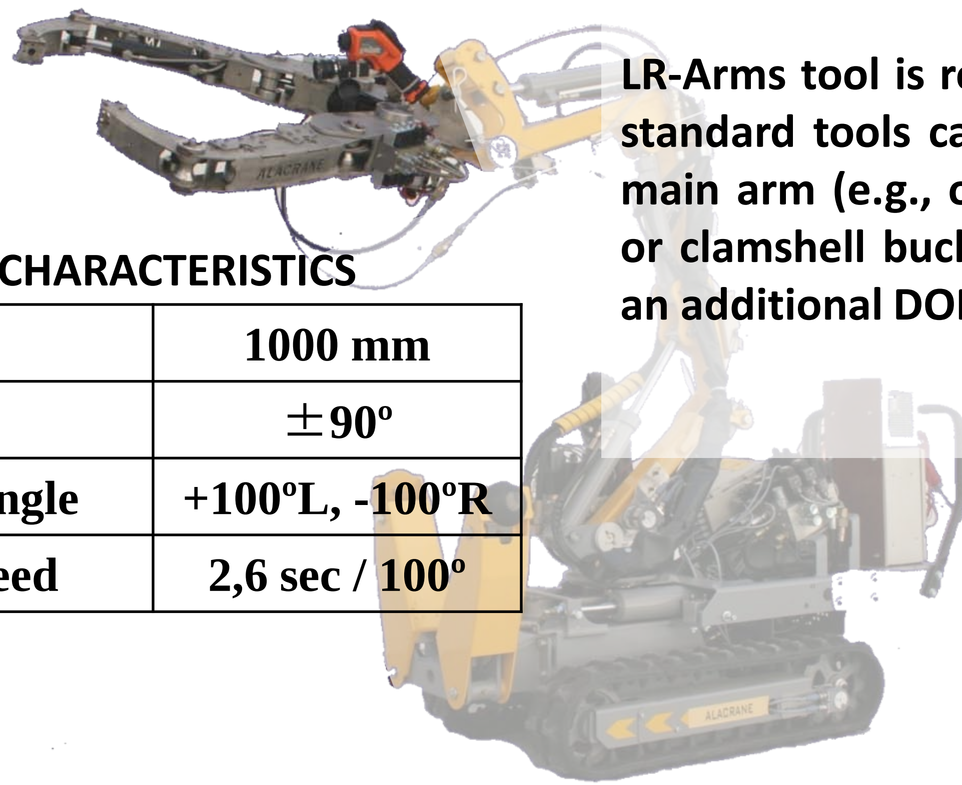
II. The Mechatronic System of Alacrane (cont…)

A) Mechanical Design.

3) The LR-Arms: It consists on a dual manipulator configured as left and right Arms (LR-Arms).

It has 7 DOF: it adds an additional DOF to the main arm (q_6), and 3 DOF for each manipulator (q_{L7} to q_{L9} and q_{R7} to q_{R9}, for the left and right arms, respectively)



LR-Arms tool is removable so that other standard tools can be connected to the main arm (e.g., on-off grippers, buckets or clamshell buckets, and grapples with an additional DOF).

LR-ARMS CHARACTERISTICS

Range	1000 mm
Base angle	$\pm$90º
Shoulder angle	+100ºL, -100ºR
Slewing speed	2,6 sec / 100º

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Operation Modes (Cont…)

AUTONOMY LEVELS FOR OPERATION MODES

	Autonomous	*Tele-Autonomous*	*Tele-operated*
Mode 0	enabled	enabled	enabled
Mode 1	enabled	enabled	enabled
Mode 2	disabled	enabled	enabled
Mode 3	disabled	disabled	enabled

Maintenance and development mode (Mode 0)

Arm mode (Mode 2).

Navigation mode (Mode 1).

LR-Arms manipulation mode (Mode 3).

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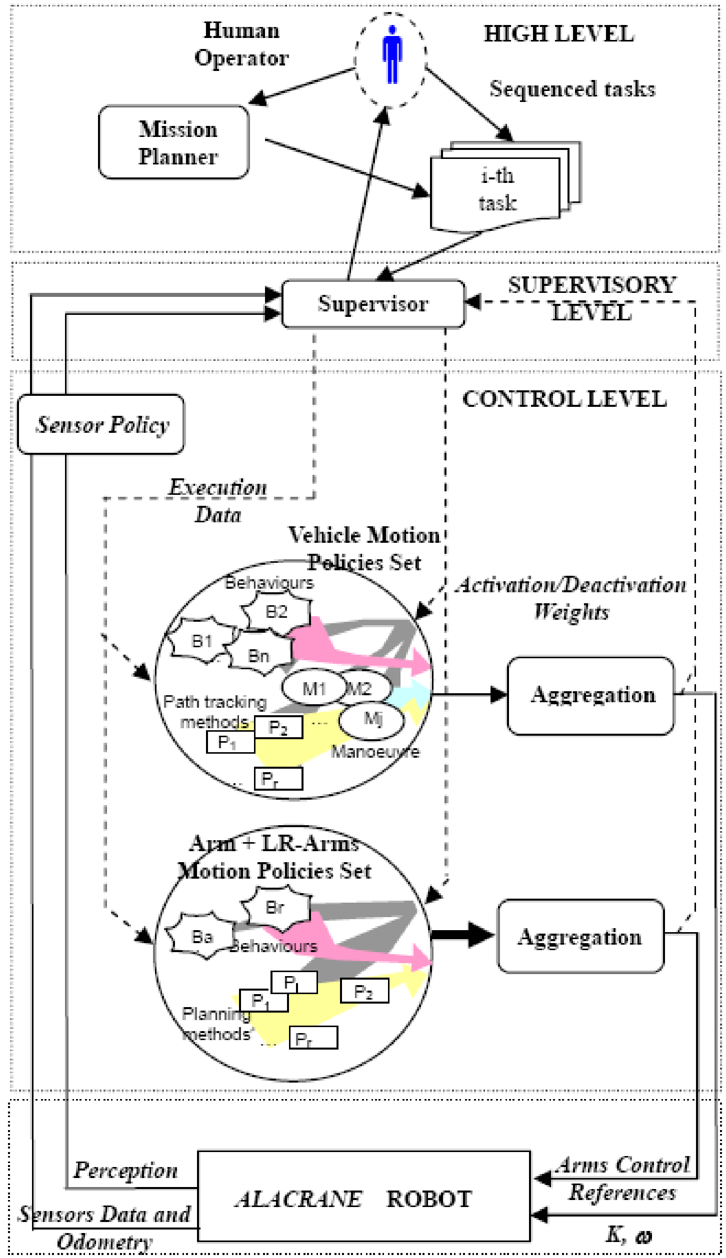
The functional architecture of ALACRANE



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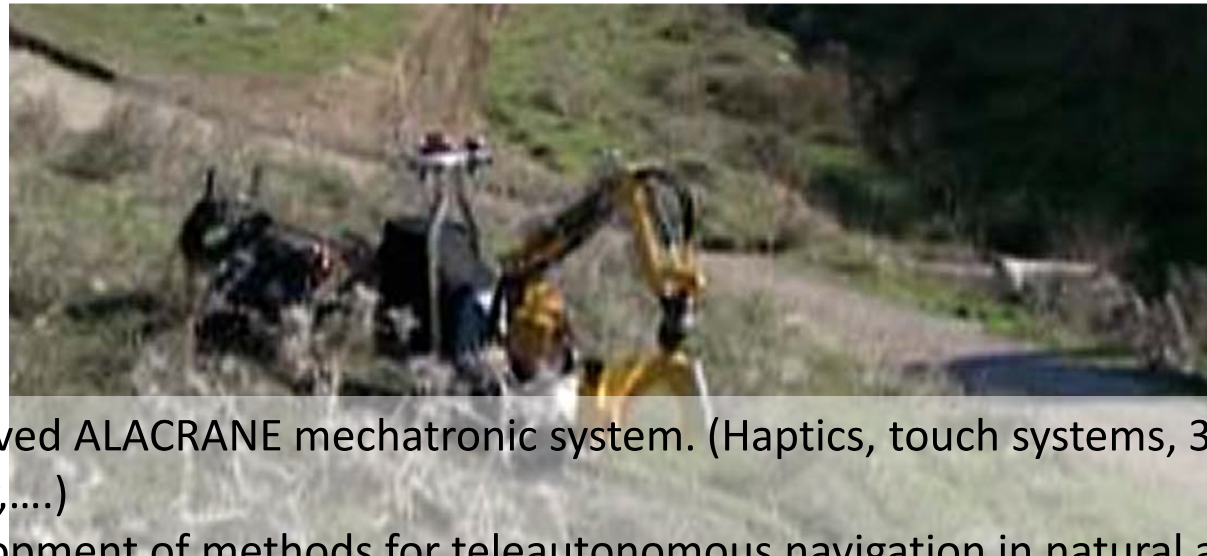
New Goals:



- Improved ALACRANE mechatronic system. (Haptics, touch systems, 3D scanner,….)
- Development of methods for teleautonomous navigation in natural and disaster areas.
- Development of maneuver in rough terrain

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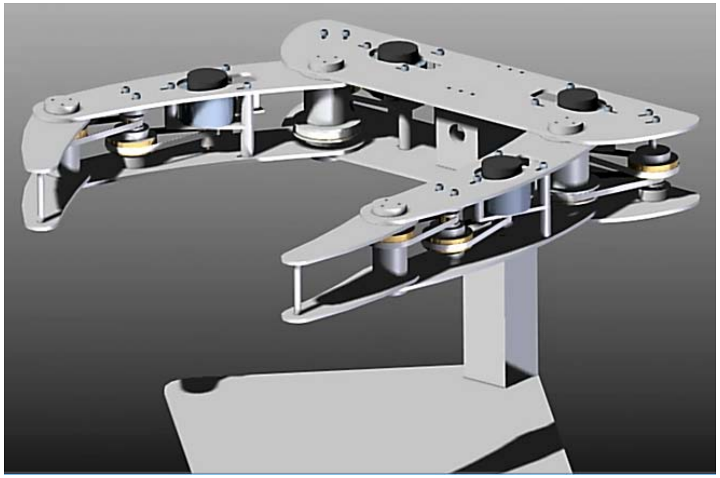
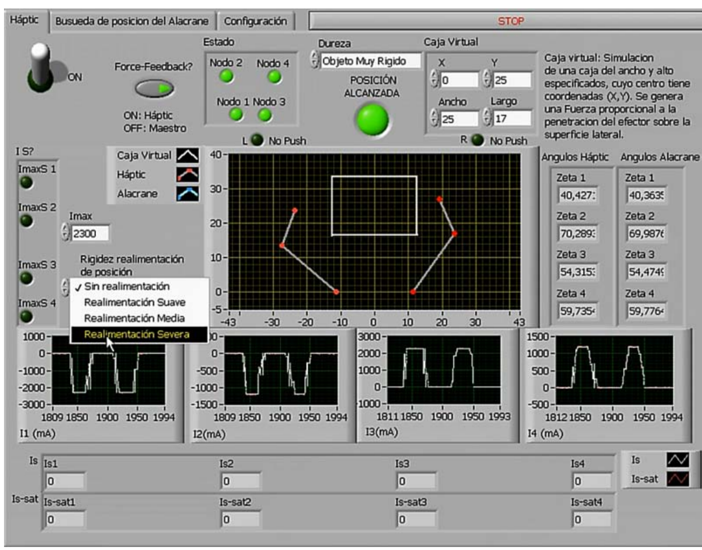
MECATRONIC SYSTEM



Haptic devices:



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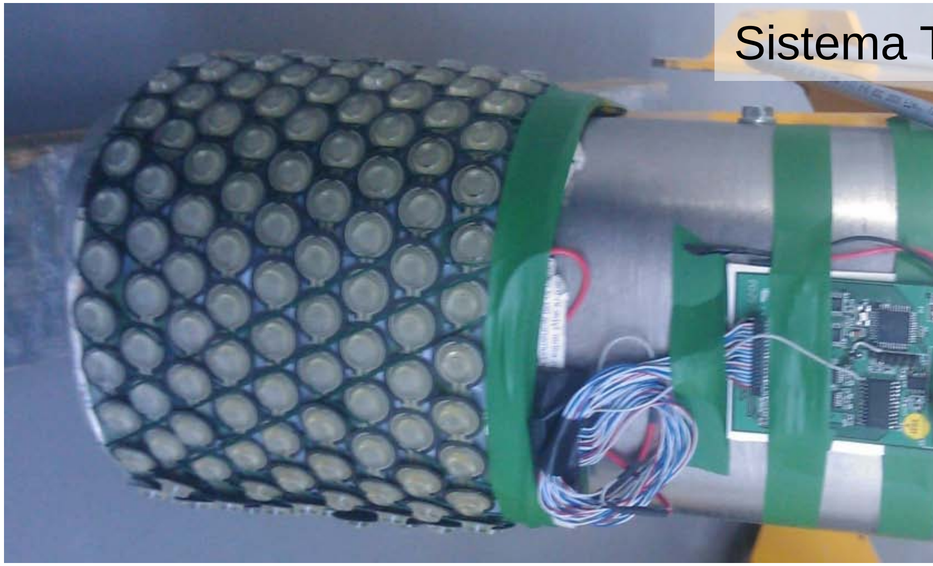
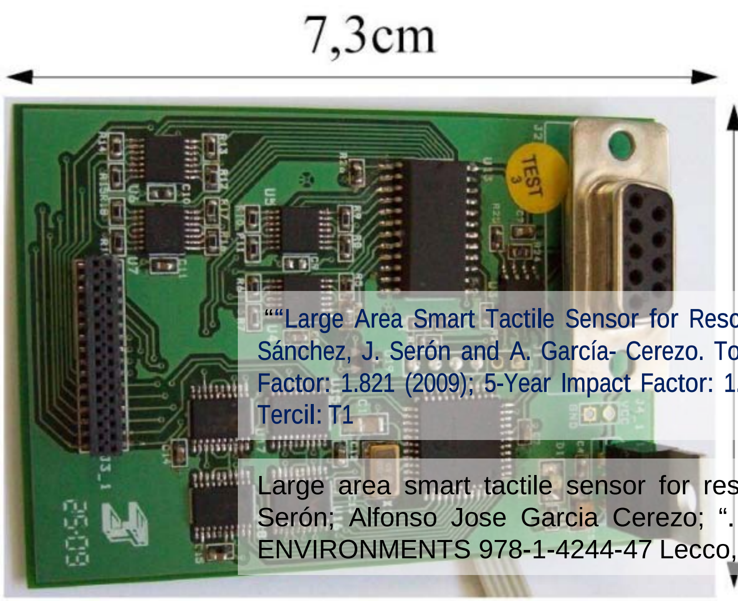
Sistema Táctil





""Large Area Smart Tactile Sensor for Rescue Robot".. F. Vidal-Verdú, M.J. Barquero, J. Castellanos, R. Navas, J.A. Sánchez, J. Serón and A. García- Cerezo. To appear in Sensors, MDPI Publishing. año: 2011 (ISSN 1424-8220) Impact Factor: 1.821 (2009); 5-Year Impact Factor: 1.903 en 2009. Posición 11/56 Área: INSTRUMENTS & INSTRUMENTATION; Tercil: T1

Large area smart tactile sensor for rescue robot" Fernando Vidal Verdu; María José Barquero; Javier Serón; Alfonso Jose Garcia Cerezo; ". INTERNATIONAL WORKSHOP ON ROBOTIC AND SENSOR ENVIRONMENTS 978-1-4244-47 Lecco, 2009

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Patente: "Telemetro 3D y procedimiento de obtención mediante cabeceo de un telemetro 2D alrededor de su centro óptico". P201001410. Application Date: 3/11/2010. Authors: García-Cerezo, Martínez, Morales, Mandow, Reina, Pequeño, Fernández. Transferida a la industria. Comercializada por INGENIERIA-UNO S.L.

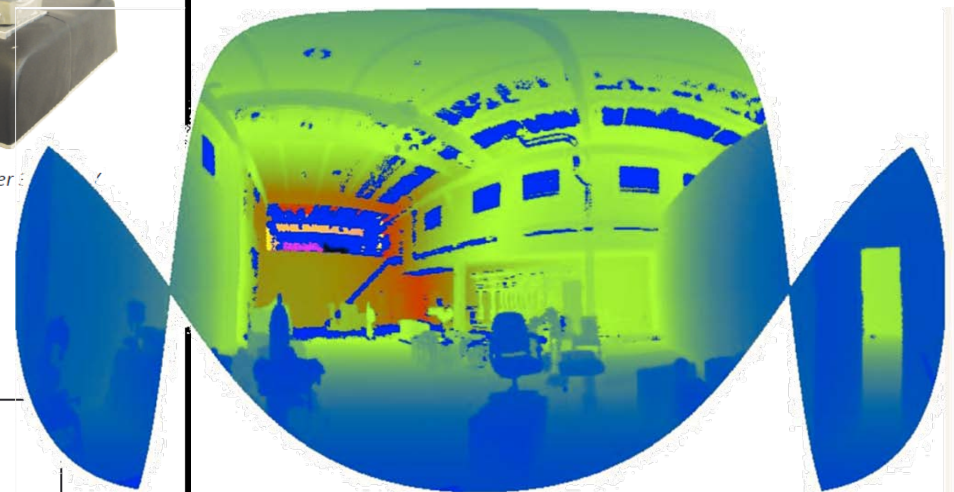
LC3DLaser Low-Cost 3D Laser Scanners 30M135Y

Technical specifications

Product Name	Low-cost 3D Laser Range Finder
Model	30M135Y
Supply voltage	12 VDC ± 10%
Supply current	1.2 A (nominal) 2.8 A (maximum)
Host interface	USB 2.0 (Virtual COM)
Detection range	0.1-30 m
Measurement resolution	1 mm
Field of view	270° x 135°
Maximum angular resolution (static mode)	0.25° x 0.001347°
Maximum angular resolution (continuous mode)	0.25° x 0.067367°
2D Scanning time	50 ms
3D Scanning time	1.54 s (minimum resolution)
Dimensions	182mm x 80mm x 191 mm
Weight	850 g

LC3DLaser

Dimensions:



Design and Development of a Fast and Precise Low-Cost 3D Laser Rangefinder Jesús Morales, Jorge L. Martínez, Anthony Mandow, Alejandro Pequeño-Boter, and Alfonso García-Cerezo. IEEE International Conference on Mechatronics. Estambul, Turquía. 13-15 de Abril de 2011

UNO Engineering May 2010

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3D Map generation

Spherical subsampling

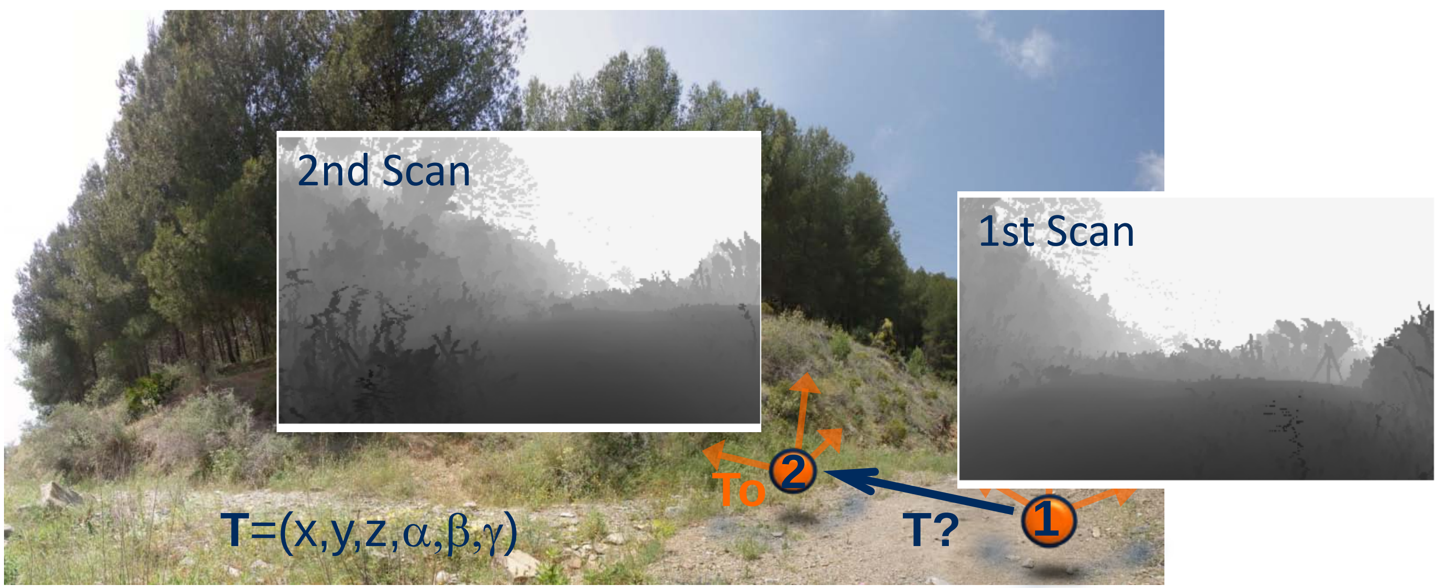
"Fast range-independent spherical subsampling of 3d laser scanner points and data reduction performance evaluation for scene registration". Antonio Mandow Andaluz; Jorge Luis Martinez Rodriguez; Antonio Jesus Reina Terol; Jesús Morales Rodriguez. PATTERN RECOGNITION LETTERS 0167-8655; Vol 31 pp1239-1250 2010 Base: SCI Área: COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE Indice de impacto: 1.303 : 54/103 Tercil: T2

Scene Registration from Data with Coarse Binary Cubes

"Outdoor Scene Registration from 3D Laser Range Data with Coarse Binary Cubes". J. L. Martínez, A. Mandow, A. Reina y J. Morales (2009). Proc. 35th Annual Conference of the IEEE Industrial Electronics Society, Oporto, Portugal.

Two Step Consistent Pose Estimation (CPE),

"Incremental Closed-Form Solution to Globally Consistent 2D Range Scan Mapping with Two-Step Pose Estimation". J. L. Martínez, J. Morales, A. Mandow y A. García-Cerezo (2010).. Proc. 11th International Workshop on Advanced Motion Control. Nagaoga (Japón).



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PATH PLANNING

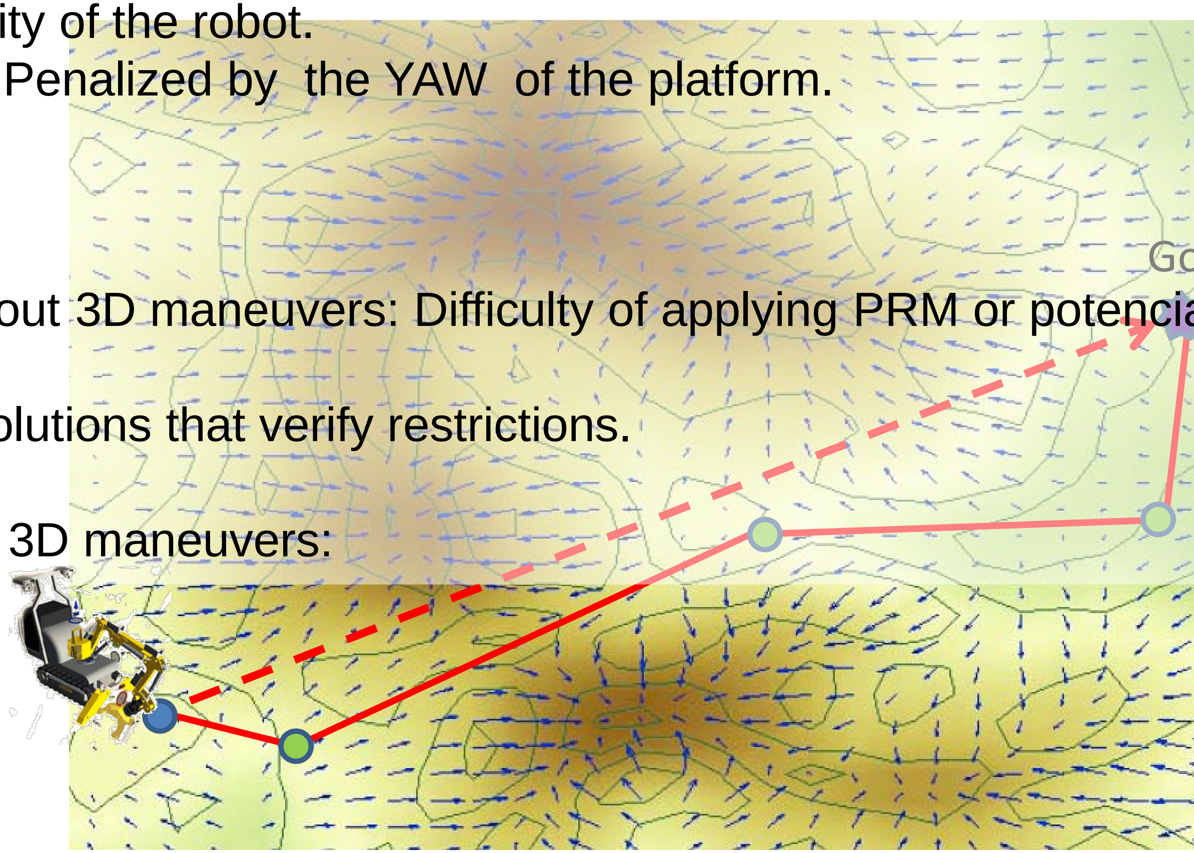
<u>restrictions:</u>
Maneuverability: ROLL depend on the vehicle and arm position.
Static and dynamic stability of the platform.
Center of gravity of the robot.
Consumption: Penalized by the YAW of the platform.

-Way points.

-Planning without 3D maneuvers: Difficulty of applying PRM or potenciaal fields.

-Suboptimal solutions that verify restrictions.

-Planning with 3D maneuvers:



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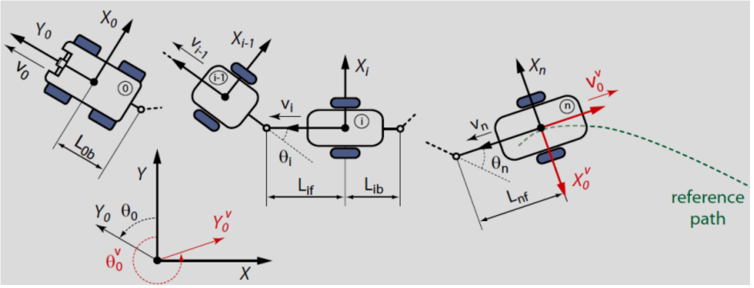
3D MANEOUVERS

- Center of gravity modification

- Multitrailer operations.

'Last trailer ≡ virtual tractor' backward motion strategy.

→ extension to several heterogeneous off-axle trailers in backward motion



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- Rotation with arm resting on the floor

- Ground Sleve

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•Up/Down an obstacle (Forward and backward)

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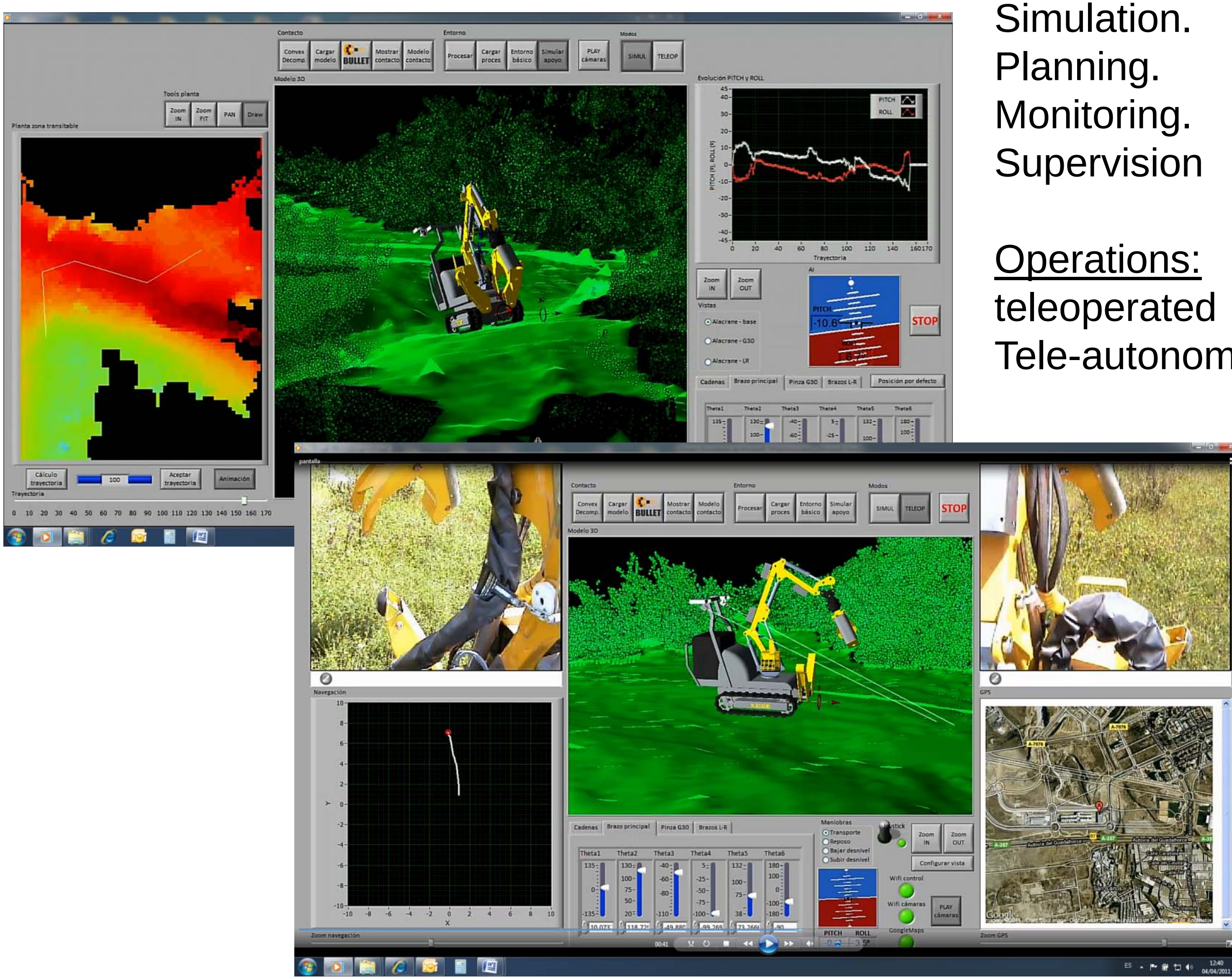
BASE STATION :



Simulation.
Planning.
Monitoring.
Supervision

<u>Operations:</u>
teleoperated
Tele-autonomous

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<u>New Challenges:</u>

DPI2011-22443. "**RAMBLER: Towards Autonomy in Long-Range Exploration Robots in Natural Environments.**"

Redesign the vehicle for outdoor navigation

Introduction of (active) suspension

Sensing is another relevant aspect of outdoor navigation

Real 3D Simultaneous Localization and Mapping (SLAM)

GPS-denied environments

Environment Modeling in 3D Natural Environments

Markov random fields and fuzzy logic

Navigation in natural environments

decision making abilities at different cognitive levels,

with different degrees of autonomy under the supervision of human operators

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LONG-RANGE NAVIGATION.

From the perspective of the robot, the goal is to develop navigation strategies based on the environment model, and the use of cognitive tools for decision making. Also, cognitive tools will be used for system monitoring and missions evaluation to be implemented from the base station.

Path planning in natural and non-structured 3D environments. Simplified version development of the configuration space C-Space (velocity space, trajectory-parameter space,…). Trajectory generation. Combination of multiple search criteria, such as power consumption or tip-over stability.

Local navigation planning. Implementation of reactive strategies with 3D sensors (3D scanner, time-of-flight cameras). Obstacle negotiation and negative obstacles. Fuzzy cognitive maps and decision making techniques, risk analysis, and learning.

Supervised navigation. Operation base extension. Mission supervision. Prediction model creation. Tele-autonomous operation mode. Autonomous operation mode. Mission evaluators.

ENLACES A PROYECTOS DEL GRUPO:

http://www.isa.uma.es/C10/teleoperacion/default.aspx

http://www.isa.uma.es/C8/Alacrane/default.aspx

http://www.isa.uma.es/C7/C6/Proyecto%20DPI2008-00553/default.aspx

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Gracias por su atención.

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