

Industrial robots and their integration with vision systems

State of art and future developments

DAY 2

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DENSO @K.L.A.IN robotics srl



- ~~Premessa~~
 - ~~K.L.A.IN. robotics~~
 - ~~DENSO~~
- ~~Vision systems~~
 - ~~Theory~~
 - ~~Examples~~
- Software instruments
 - Presentation
 - Examples
- Conclusion and Q&A

Strumenti





6-AXIS ROBOTS /

Ideal for:

- Assembly
- Inspection
- Matching
- Material handling
- Machine tending
- Packaging
- Palletizing
- Electrostatic welding
- Bespoke applications

Industries:

Our robots are employable in a wide variety of industries including pharmaceutical, medical and food.

Available in Protection Classes:

- Standard
- Dust & Splash Proof (IP65)
- Protected (IP67)
- Clean Room Class 10 & 100
- Hydrogen Peroxide-resistant (H₂O₂) for aseptic environments
- UL Specifications (for the USA and Canada)

Main features:

- Payloads up to 10 kg
- Arm reach up to 1300 mm
- Max. Comp. Speed up to 11 000 mm/s
- Mounting in floor, ceiling and wall

4-AXIS ROBOTS /

Ideal for:

- Pick & place
- Assembly
- Packaging
- Dispensing
- Inspection
- Material removal
- Material handling
- Bespoke applications

Industries:

Our robots are employable in a wide variety of industries including pharmaceutical, medical and food.

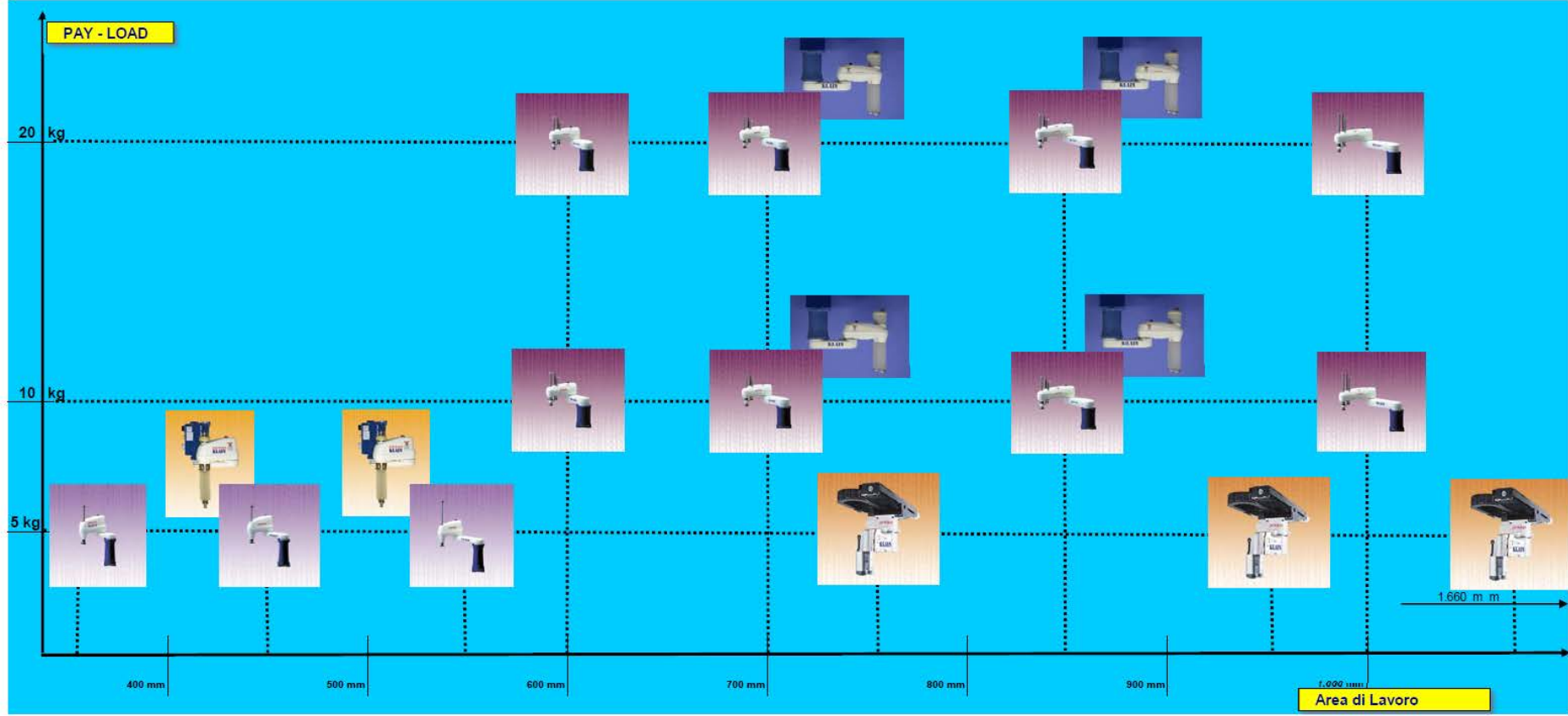
Available in Protection Classes:

- Standard
- Dust & Splash Proof (IP65)
- Clean Room Class 10
- UL Specifications (for the USA and Canada)

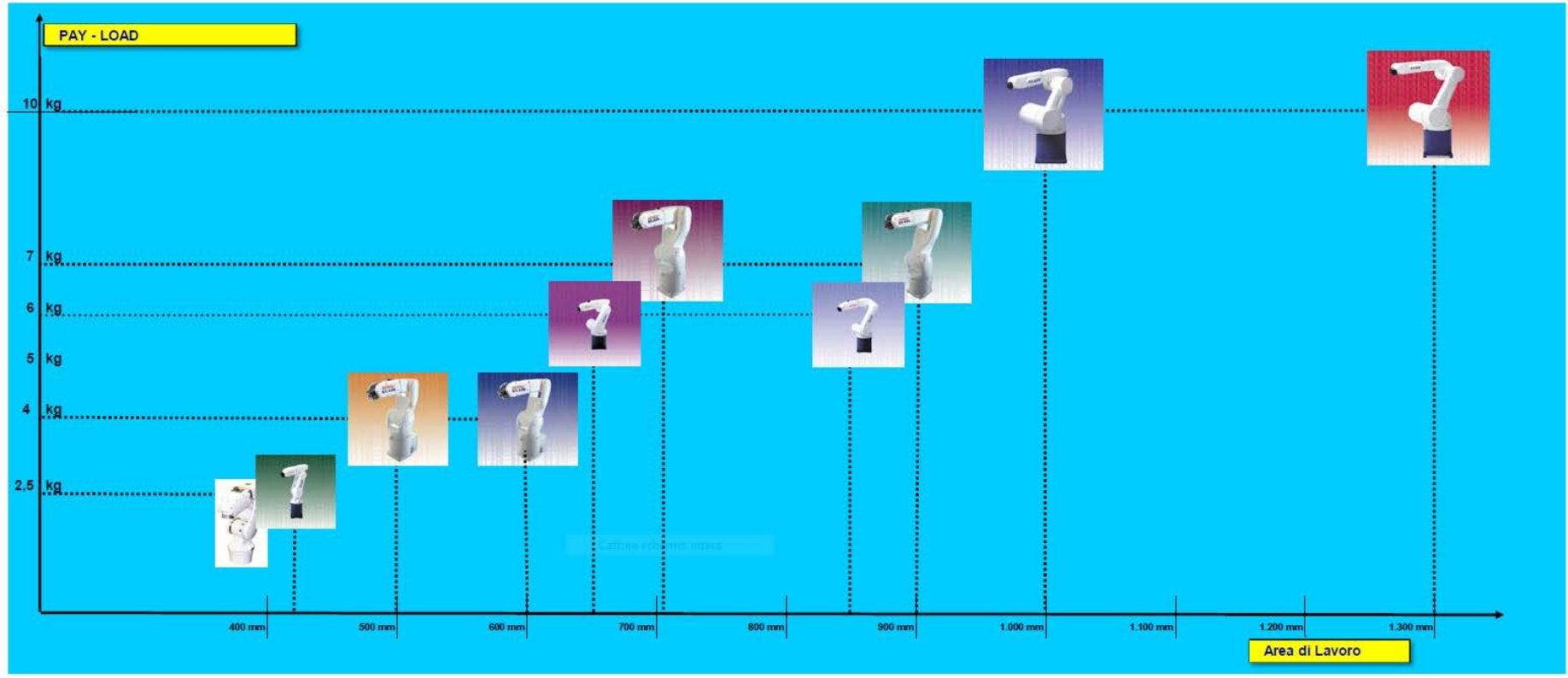
Main features:

- Payloads up to 20 kg
- Arm reach up to 1000 mm
- Max. Comp. Speed up to 11 500 mm/s
- Mounting in floor and ceiling

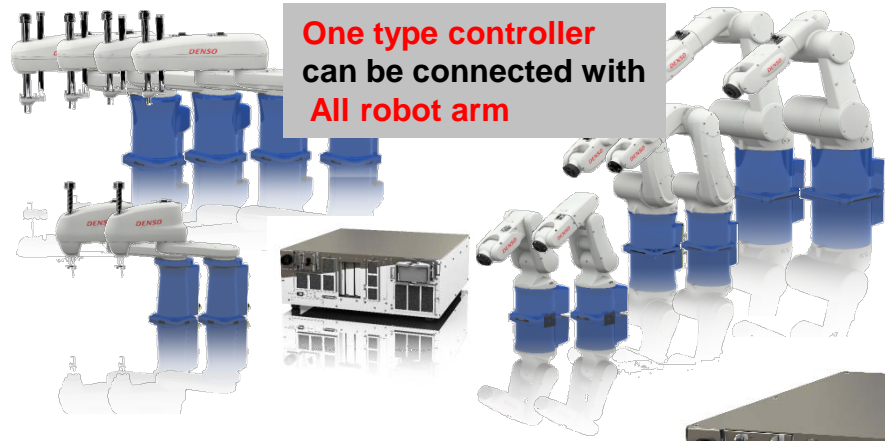
GAMMA ROBOT SCARA DENSO



GAMMA ROBOT ANTROPOMORFI DENSO



Maintainability



**One type controller
can be connected with
All robot arm**

Extendibility

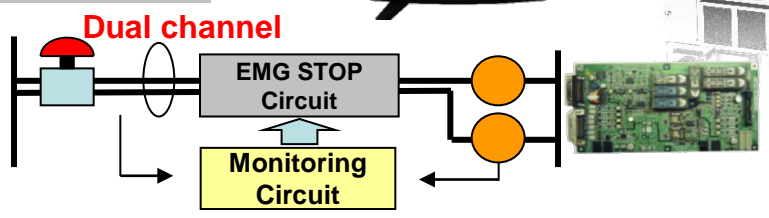
| Standard: | Option: |
|-------------------------|-------------------------------------|
| Mini I/O 16 / 16 | Extension I/O board 40(80) / 48(96) |
| Hand I/O 8 / 8 | RS-232C +2ch |
| 1 x Ethernet (100 Base) | Profibus Slave 256 / 256 |
| 2 x USB | DeviceNet Slave 256 / 256 |
| 1 x RS-232C | DeviceNet Master 1024 / 1024 |
| | DeviceNet Master & Slave |
| | Conveyor tracking |



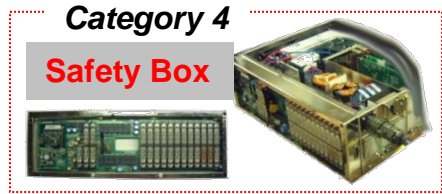
MODE Select KEY



Safety Circuit



Lock out



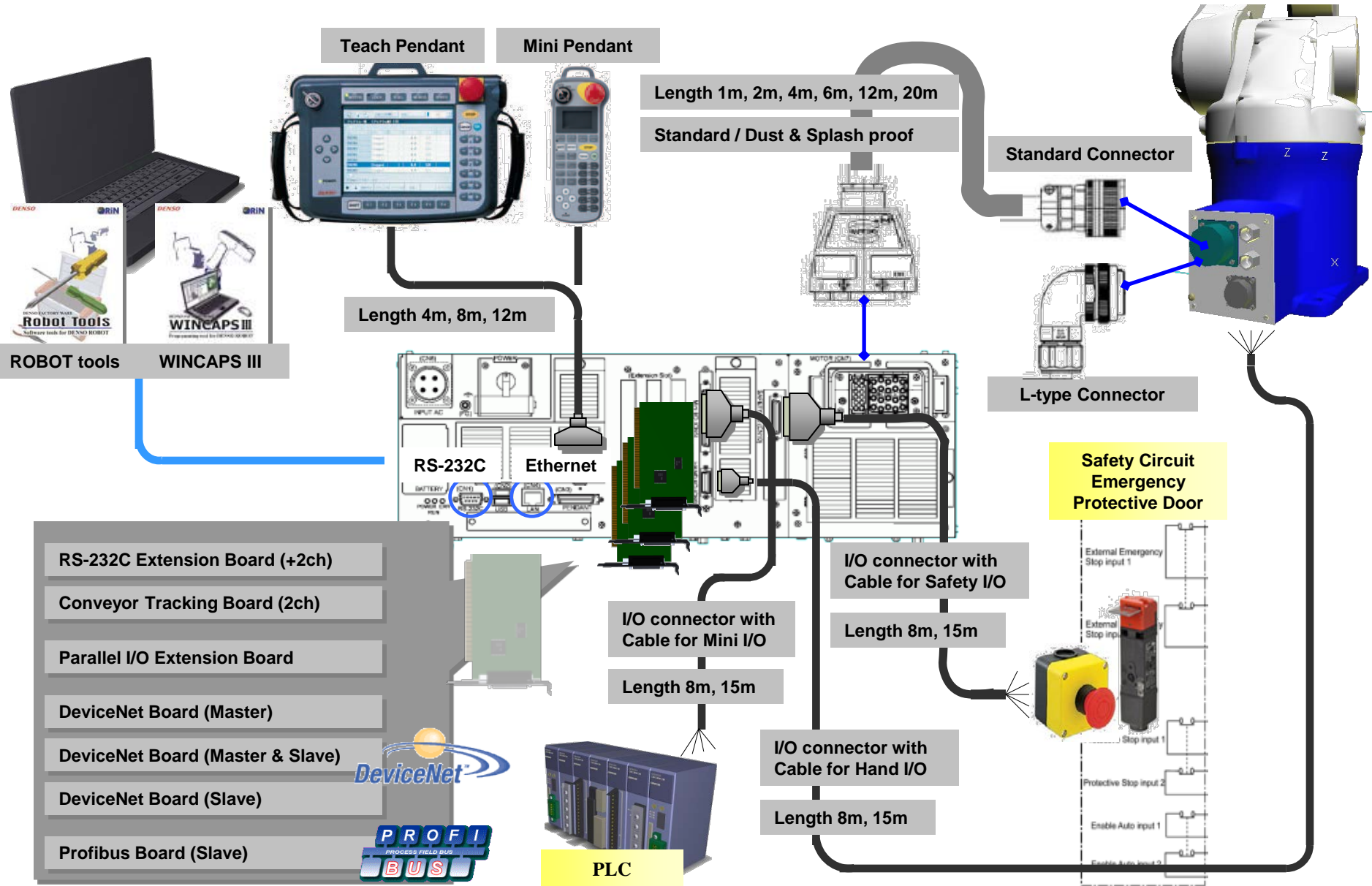
Panel Designer for Windows



**Display 7.5 inch
Dust & Splash proof IP65**

Safety

Usability



- **Simulation and Development (PC-based solutions)**
 - **WINCAPS III.** DENSO's offline programming, monitoring and simulation software
 - **ORiN2.** Middleware to program our robots and other devices such as PLCs, HMIs, servo motors, etc. with high-level programming languages such as C++, C#, VB, among others.
 - **b-CAP.** Control protocol incumbent of any platform or programming language to program DENSO robots and peripheral devices using a PC, PLC or other device which incorporates Ethernet TCP/IP or UDP
 - **ORiN Vision.** Extensive vision library designed exclusively for ORiN2
 - **HALCON Extension Package.** For experienced HALCON users (powerful software for machine vision) for programming vision and robotics applications

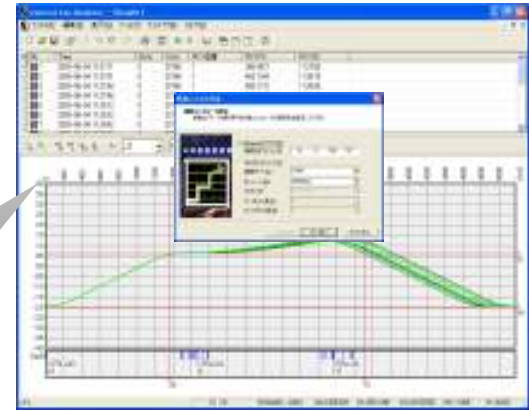
- **Software Tools**

- **e.vision.** Configuration tool for setting up vision and robotics applications with Anyfeeds from Flex Factory. This software is intended for non-experienced users of computer vision.
- **Robot Tools.** Suite of utility tools that enables the optimum maintenance and operation of DENSO robots

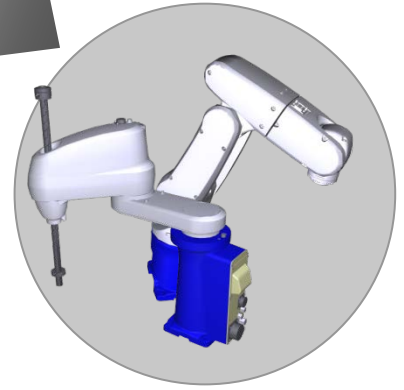
- **Third-party Software**
 - **3DCreate.** Powerful software for simulation complete factory layouts and robotics applications
 - **ROSY.** Tool for achieving advanced levels of precision in DENSO robots for special applications



Virtual TP

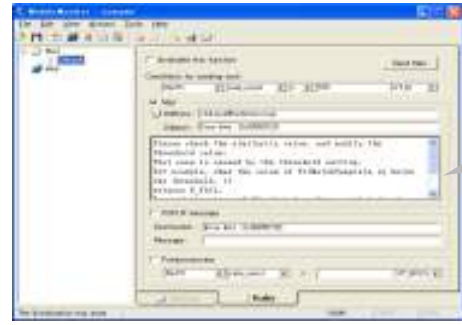


Control Log Analyzer



DENSO Robot

Support software for robot
operation and maintenance



Mobile Monitor

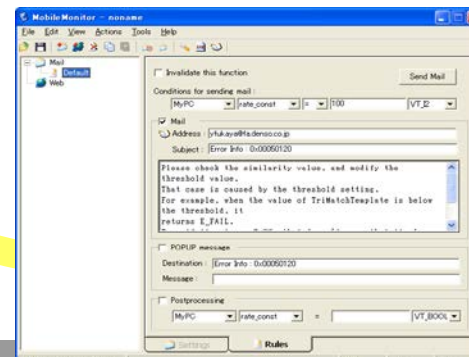
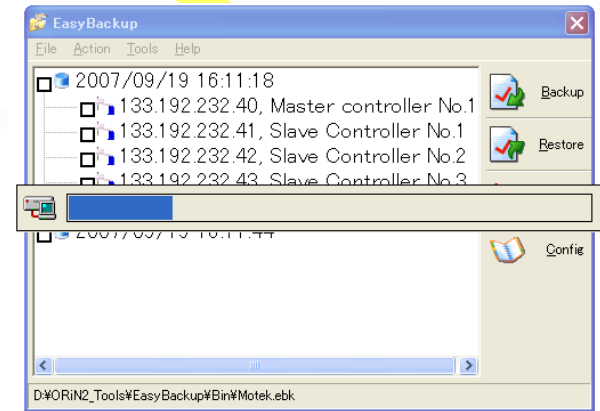
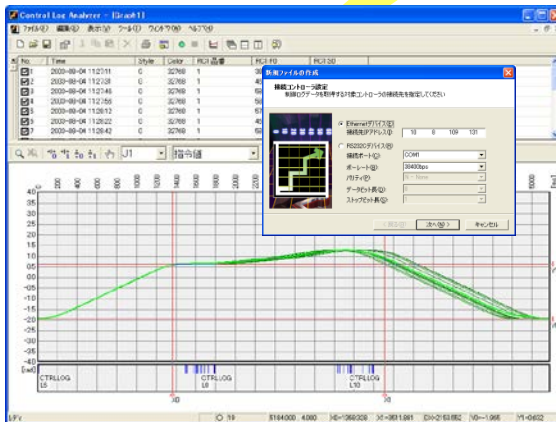


Easy Backup

Strumenti di diagnostica e assistenza per Robot DENSO

Robot Tools

- Strumenti di sistema per ORiN2 -

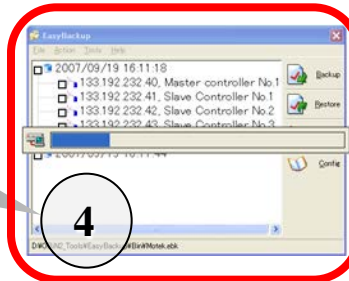
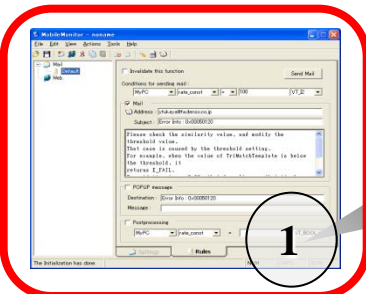
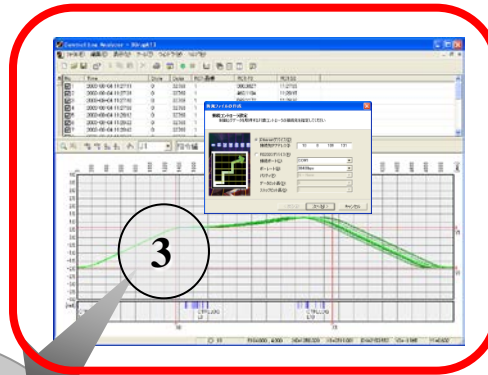
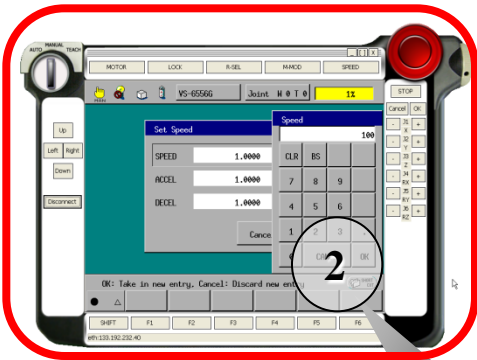


Cosa è Robot Tools?

- “Robot Tools” è un insieme di strumenti per l’assistenza e la diagnostica dei robot DENSO .
- “Robot Tools” consiste in 4 applicazioni ORiN2.
 - Mobile Monitor : Notifica istantanea dell’errore via e-mail
 - TP Virtuale: Teaching Pendant virtuale su PC portatile
 - Control Log Analyzer : Visualizzazione e diagnostica degli “errori” e report storico degli avvenimenti
 - Easy Backup : Back-up dei programmi “mediante un semplice click” e ripristino dei dati nel Controller
- “Robot Tools” supporta la diagnostica . L’utilizzo quotidiano di questi strumenti permette l’ottimizzazione dei costi di utilizzo del robot

Applicazioni Robot Tools

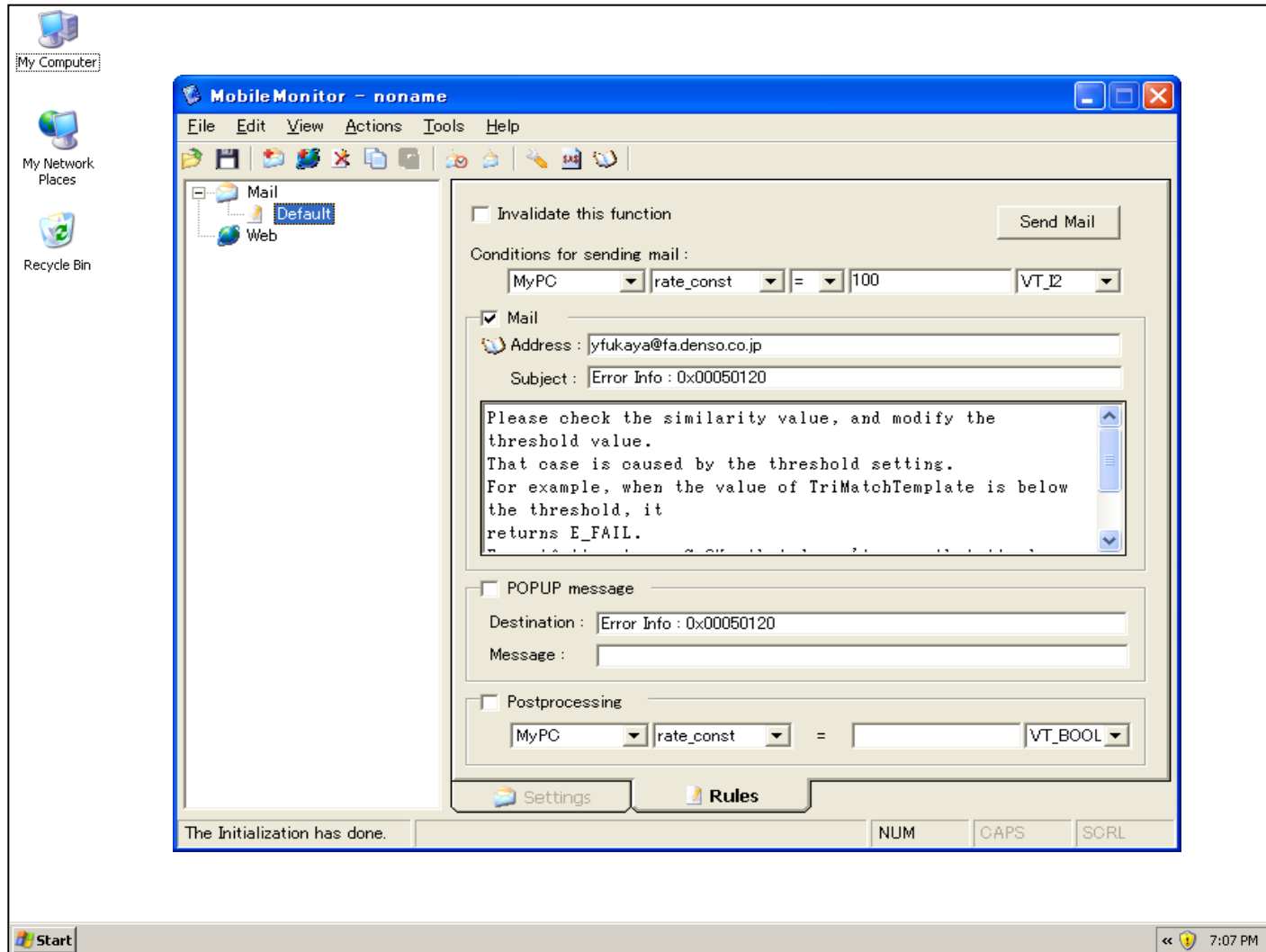
Robot Tools supporta la diagnostica giornaliera ed ottimizza i costi di utilizzo dei robot



**DENSO
Robot**

1. Mobile Monitor
2. Virtual TP
3. Control Log Analyzer
4. Easy Backup

1. Mobile Monitor



Funzioni del Mobile Monitor

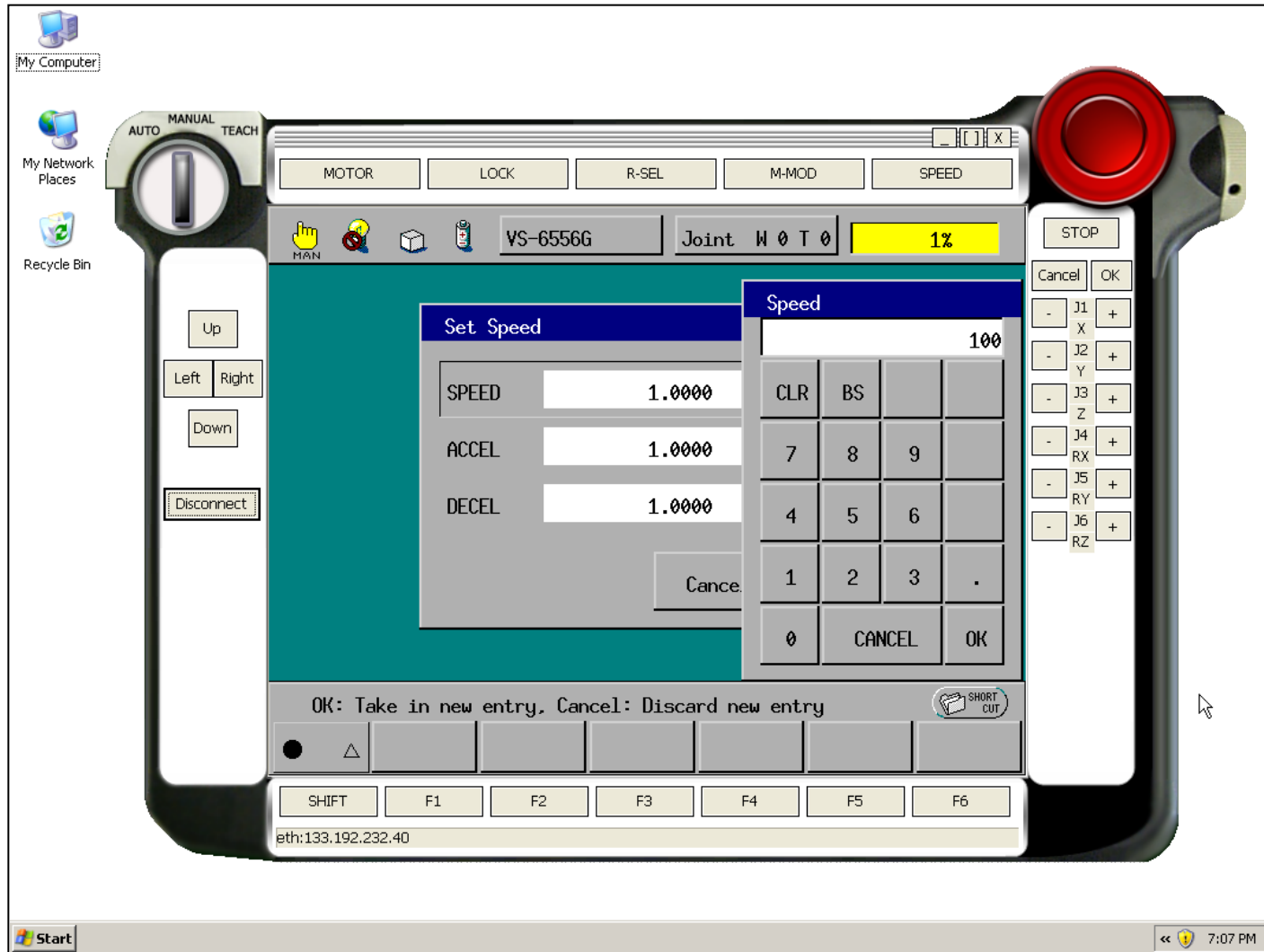
The diagram illustrates the Mobile Monitor system. On the left, a red dashed box contains a vertical bus with four robot controller units connected to it. A green arrow labeled "Monitor" points from this bus to a central computer monitor. The monitor displays the MobileMonitor software interface, which includes a configuration window for email notifications. The window shows settings for sending an email to "DemoMail@Demo.co.jp" with the subject "異常検出" (Abnormality Detection) and the message "設備に異常あり。至急現場へ急行されたし。" (Abnormality detected in the equipment. Please hurry to the site immediately). A red arrow labeled "Notifica" points from the software interface to a hand holding a PDA device. The PDA screen displays a factory floor layout with a red area indicating an error. A yellow lightning bolt strikes the PDA, and a 3D block with the text "Robot Error" is positioned below it.

Funzioni Outline

Il Software controlla lo stato, ed invia , in caso di anomalia un messaggio e-mail al responsabile della produzione inerentemente all'anomalia del funzionamento.

Vantaggio : Manutenzione efficace dei Robot e “caccia” al problema

2. TP VIRTUALE

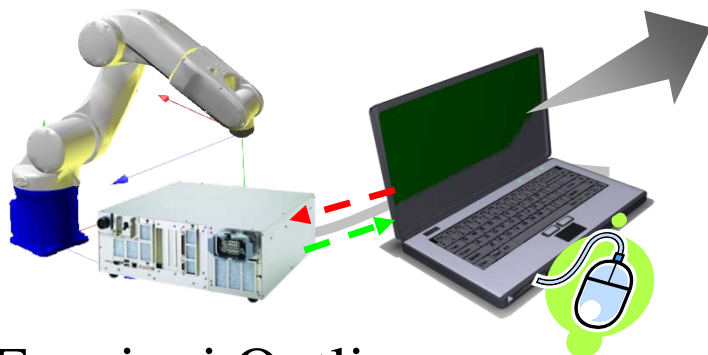


Funzioni del TP Virtuale

Operazioni in Manual Mode

Ripristino costante e ciclico dello schermo

Stesse operazioni come in caso di utilizzo del Teaching Pendant reale

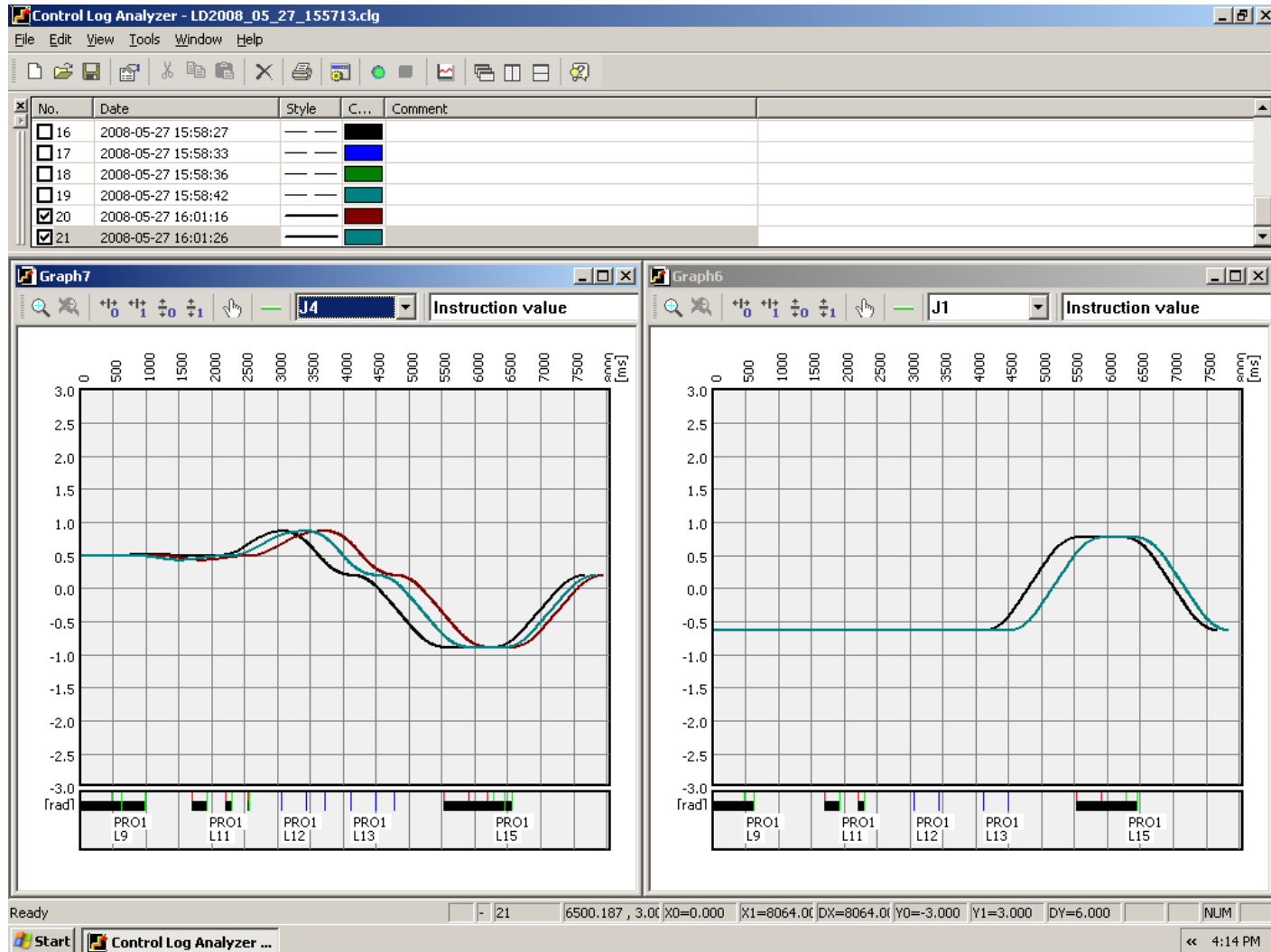


Funzioni Outline

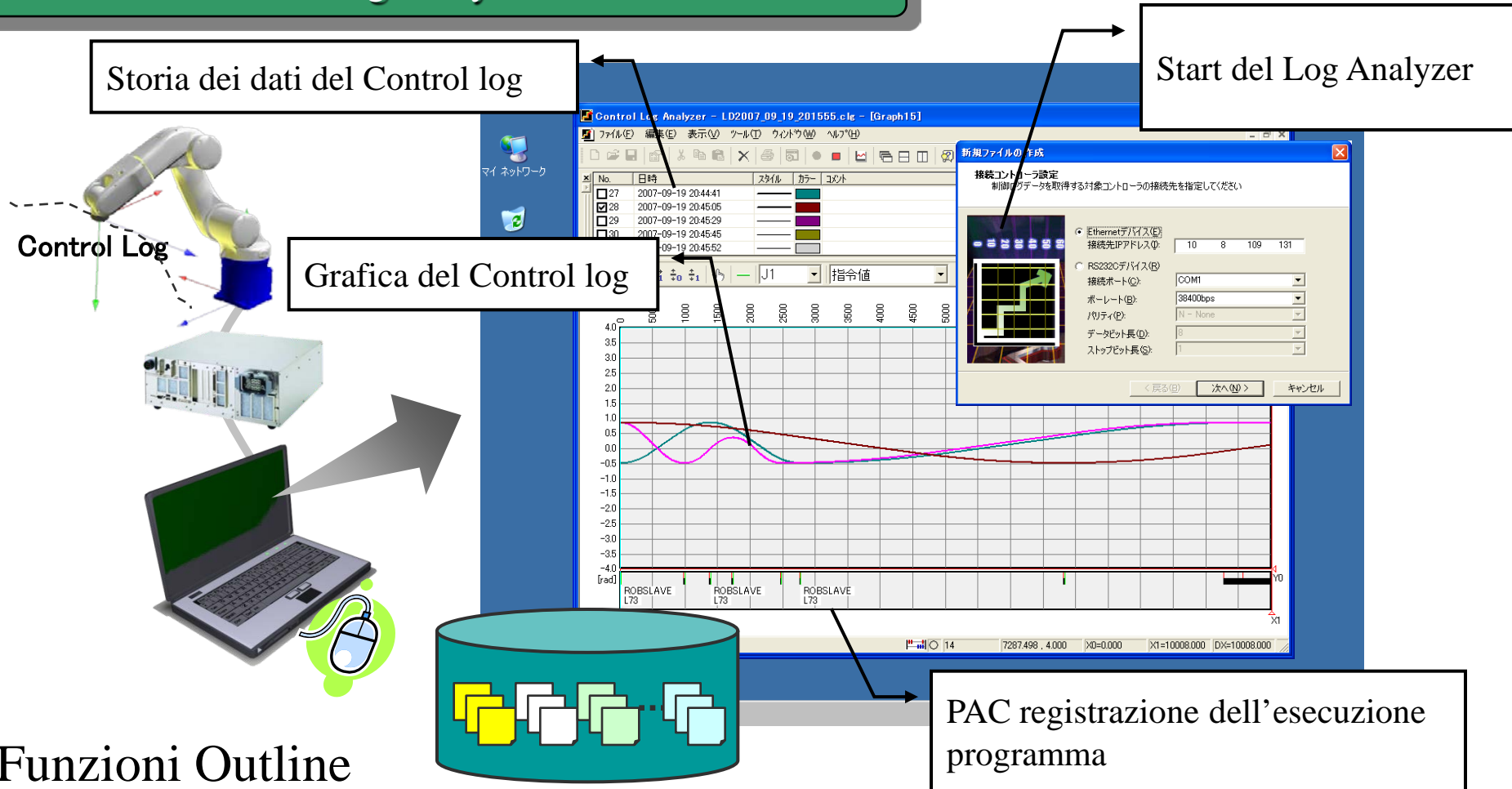
In combinazione con il Mini Pendant, il TP Virtuale supporta tutte le operazioni in manual mode.

Vantaggio : Supplemento al Mini Pendant e completo controllo del Robot

3. Control Log Analyzer



Funzioni del Control Log Analyzer

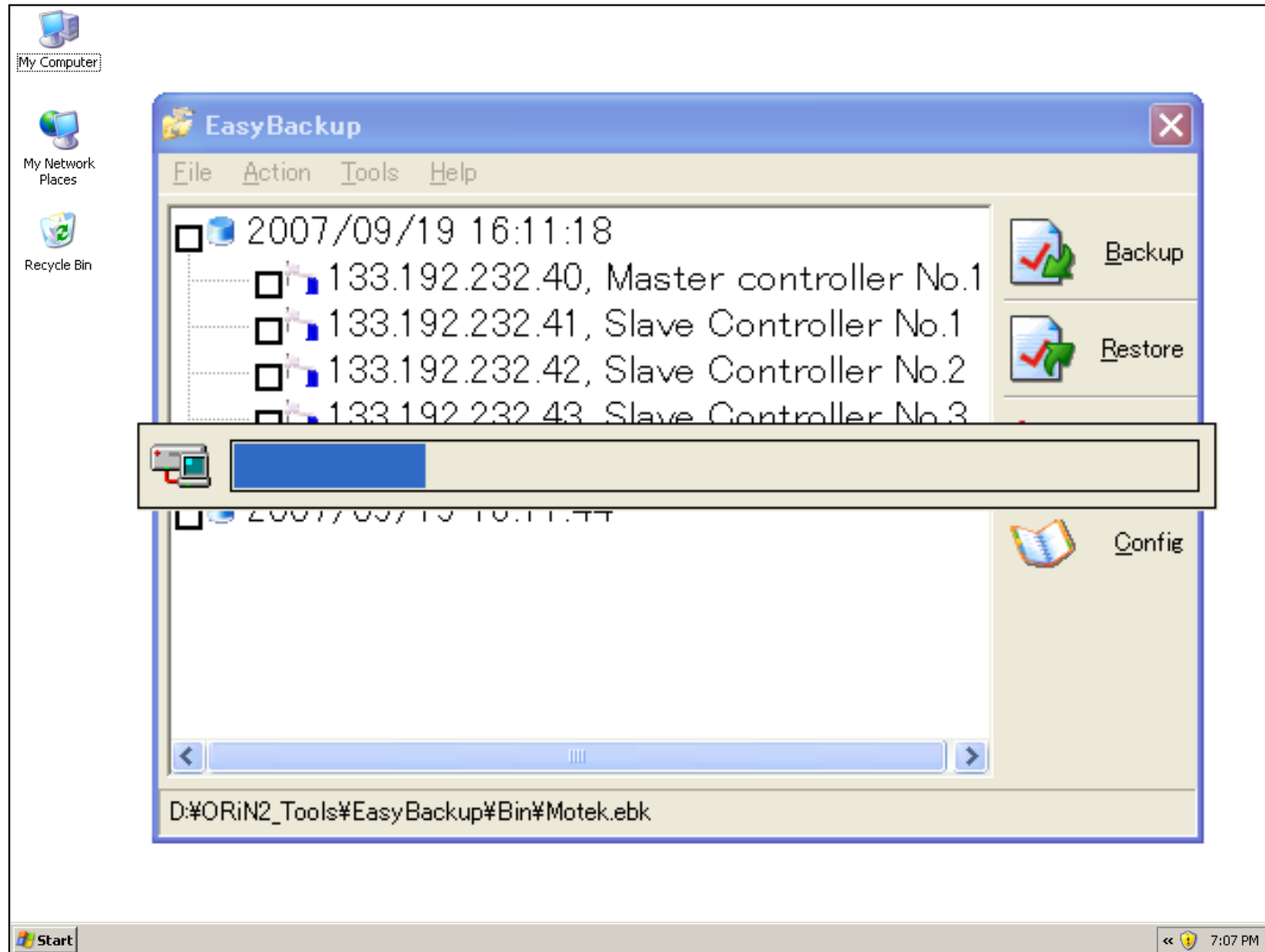


Funzioni Outline

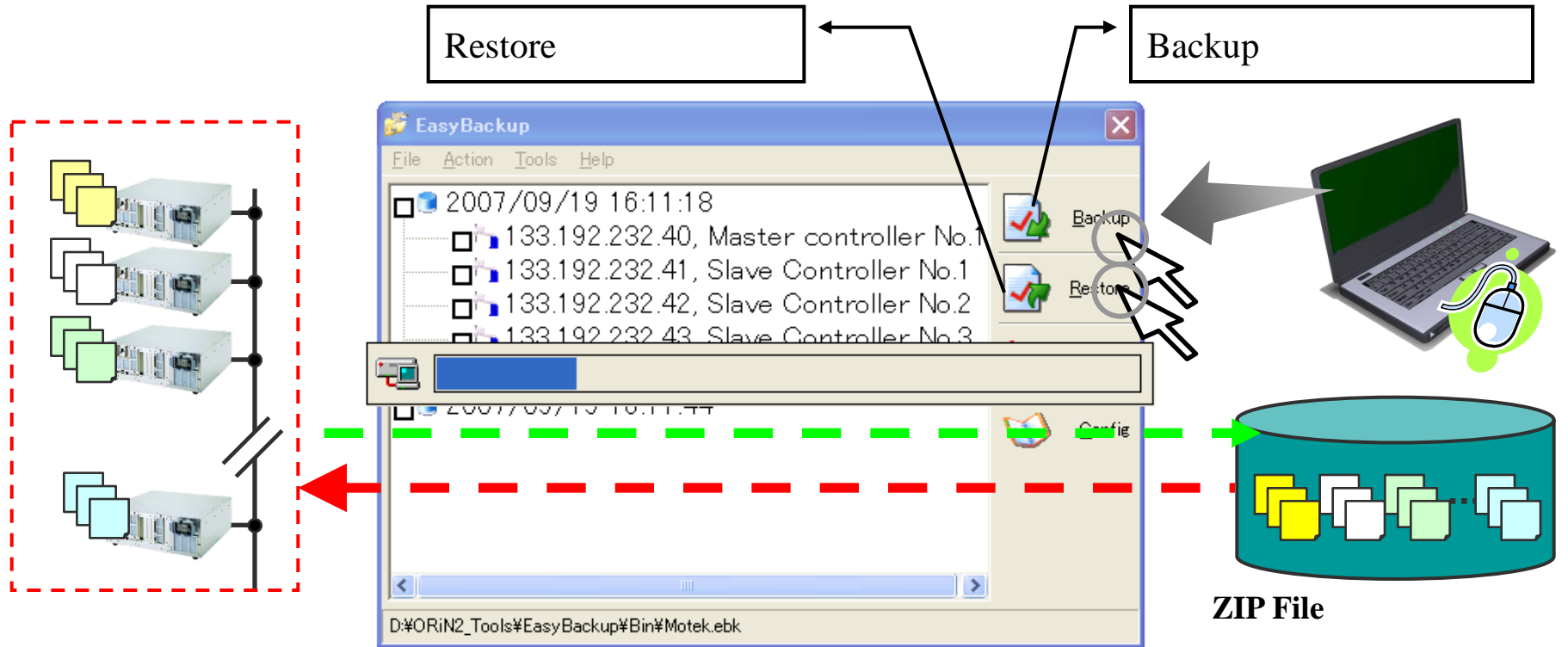
Il download dei dati, traccia il grafico dei dati di log per l'analisi visiva, e permette la verifica della correlazione tra l'errore e il Programma in esecuzione

Vantaggi : Controllo diagnostica in real-time, Visualizzazione e controllo dell'errore

4. Easy Backup



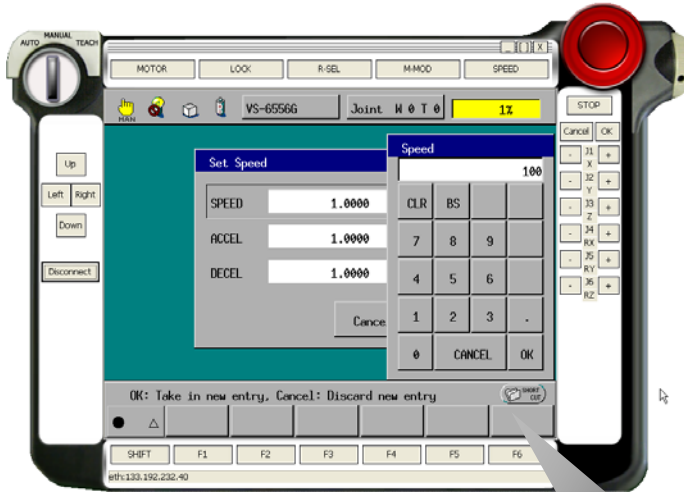
Funzioni di Easy Backup Outline



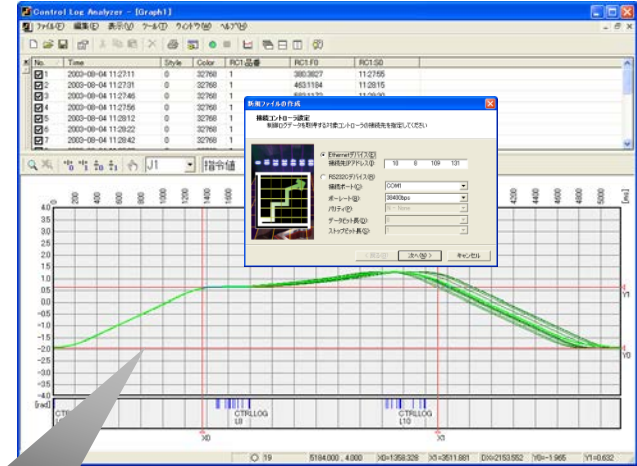
Function Outline

E' possibile eseguire il back-up e la memorizzazione totale dei dati del Controller Robot all'interno della rete , mediante una semplice operazione di "click".

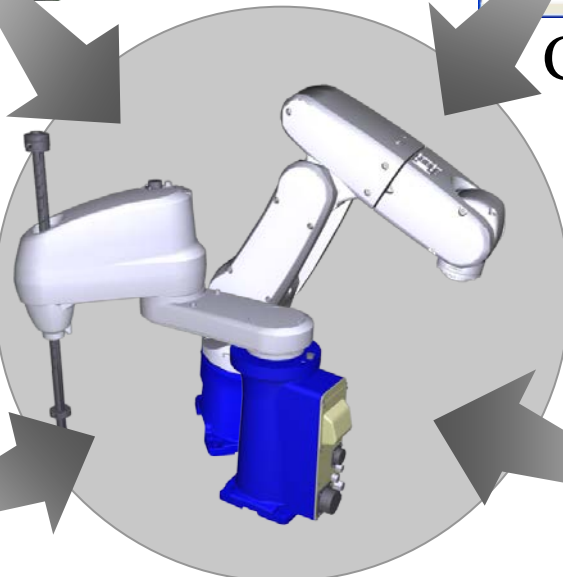
Vantaggi : Manutenzione efficace con tempi operativi più corti



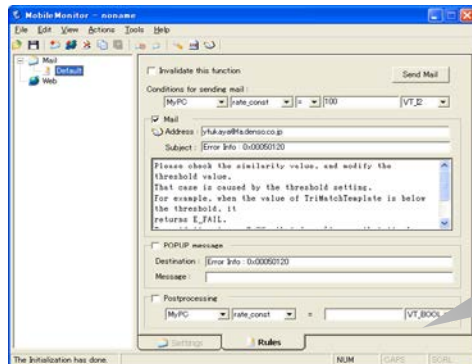
TP Virtuale



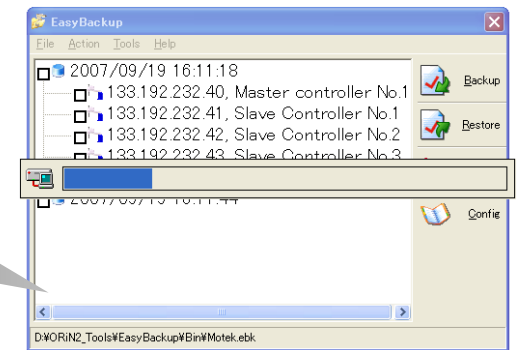
Control Log Analyzer



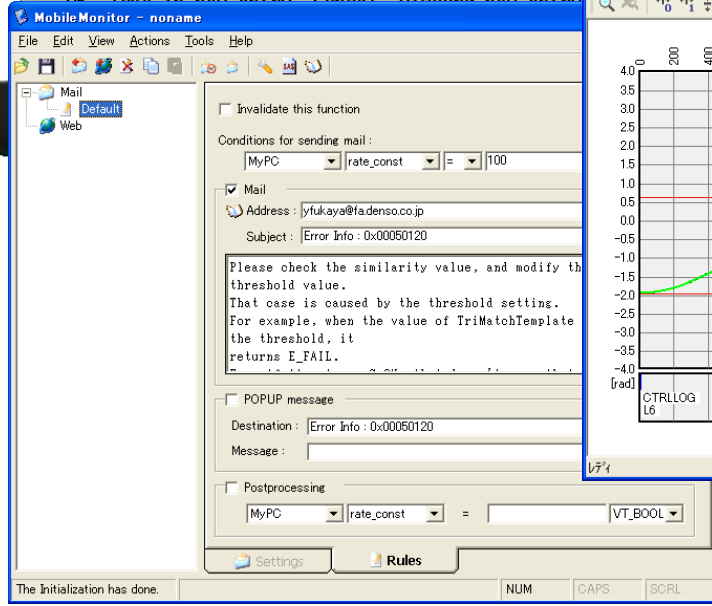
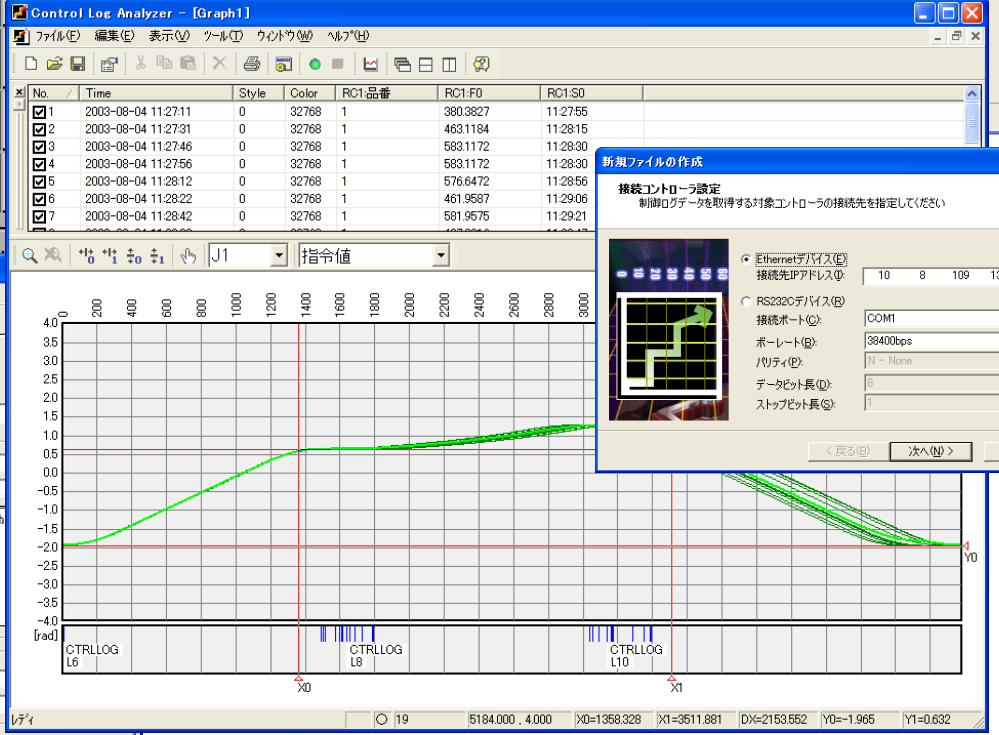
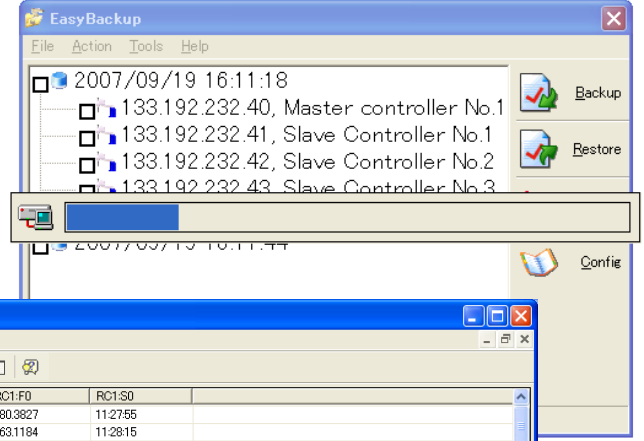
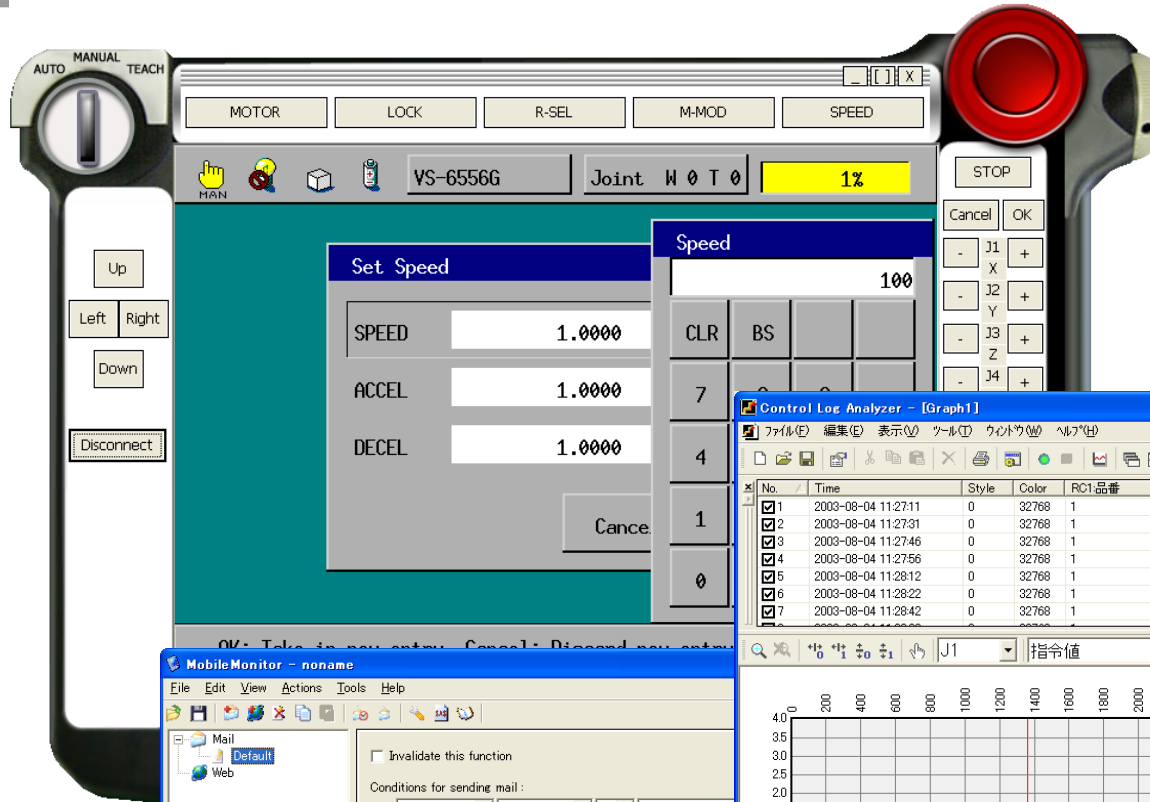
DENSO Robot



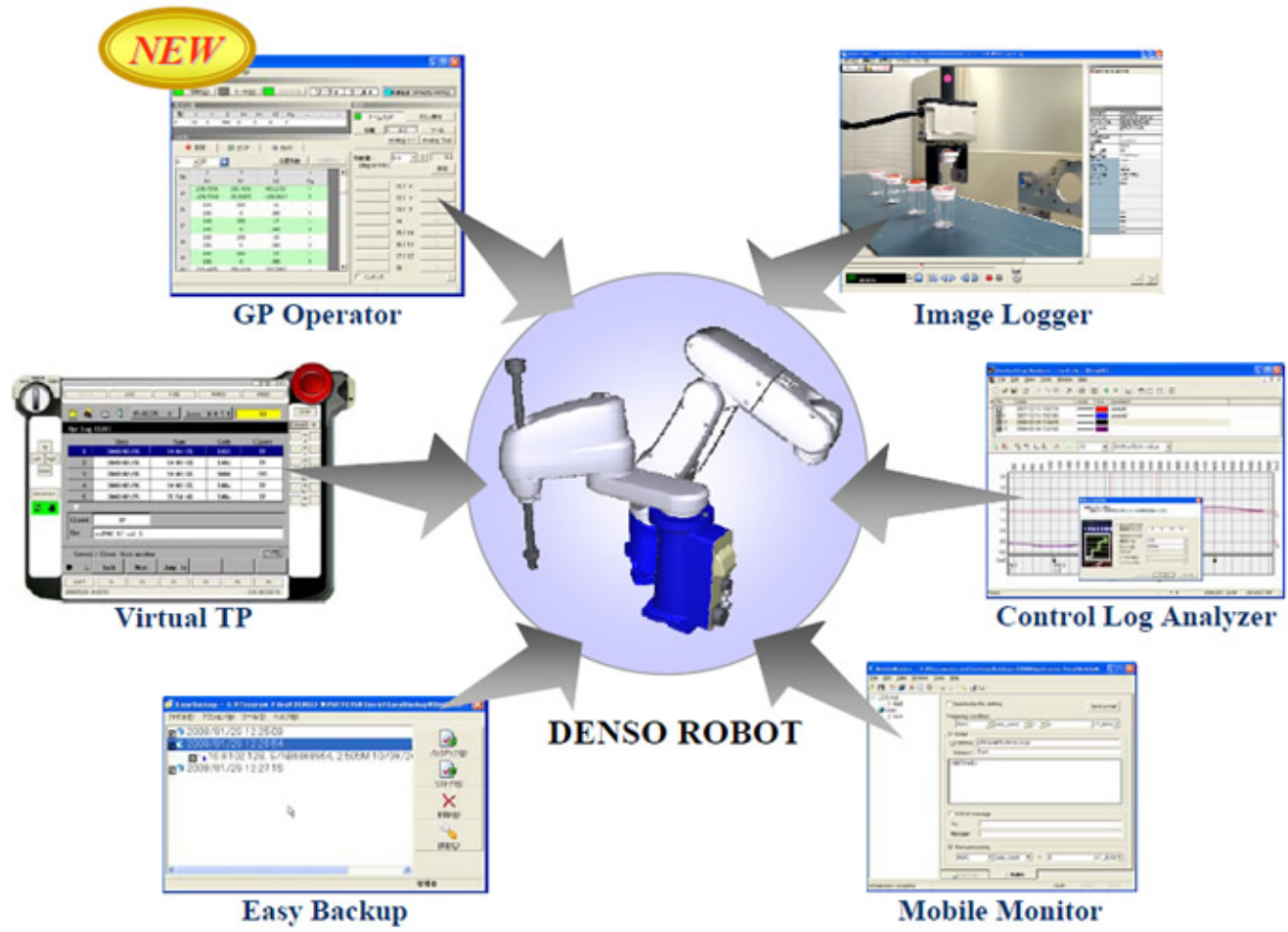
Mobile Monitor



Easy Backup



- Utility tool suite for DENSO robot operation and maintenance
- ORiN2 based applications for integrated robot management over the network
- Tools for effective daily maintenance and robot operation cost reduction

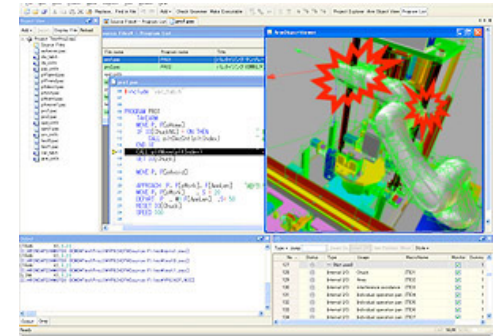


| Product name | Function |
|------------------------|---|
| GP Operator NEW | Connect your PC to a robot controller. You can operate a robot with a mouse/a gamepad easily. You can also convert a robot position into a chosen variable (P-type, J-type or T-type). It helps a developer who controls a robot with a PC on teaching. |
| Image Logger | Help to determine causes of sudden error and wrong assembly in your production. Capture images around the error and save equipment data (I/O, variable etc.). Specify the error cause through validation of the images and the data and contribute equipment improvement. |
| Virtual TP | Works with a controller set on a manual mode: various settings can be made on the GUI based Virtual TP. Robot teaching can also be done with a Mini Pendant. |
| Control Log Analyzer | Obtains Control Log from a designated controller and analyzes the robot operating status by graphing out the Control Log: visualizes the operating status. |
| Easy Backup | Backups and restores all data of multiple controllers with a single click. Consolidates the compressed data: enriches the portability and maintenance performance of robot facilities. |
| Mobile Monitor | Monitors controllers operating status and notifies errors or troubles through portable devices to an operator even not at the site. |

- Wincaps III: OLP software
- b-CAP: eth TCP/IP control protocol
- ORiN2: factory automation middleware
- ORiN vision: is the extensive vision library designed exclusively for ORiN2 middleware



- Program robot from offline PC without operating robot
- Lay out automation workcells in virtual environment
- Determine obstacle clearances, detect collisions, verify reach and cycle times
- Monitor workcell operation from remote location
- DENSO's WINCAPS III offline programming software enables users to conveniently program a robot from a remote PC without operating the robot.
- CAD drawings can be imported in standard VRML and DirectX formats, and variables can be easily entered or changed. A 3-D simulation feature allows layout of automation workcells in a virtual environment. Users can verify reach, determine obstacle clearances, detect collisions, troubleshoot and debug programs, and determine cycle time. The software also allows remote monitoring of workcell operations via 3 D simulation, realtime I/O status indicators and detailed control logs. A panel-design feature allows customization of the Teaching Pendant display.



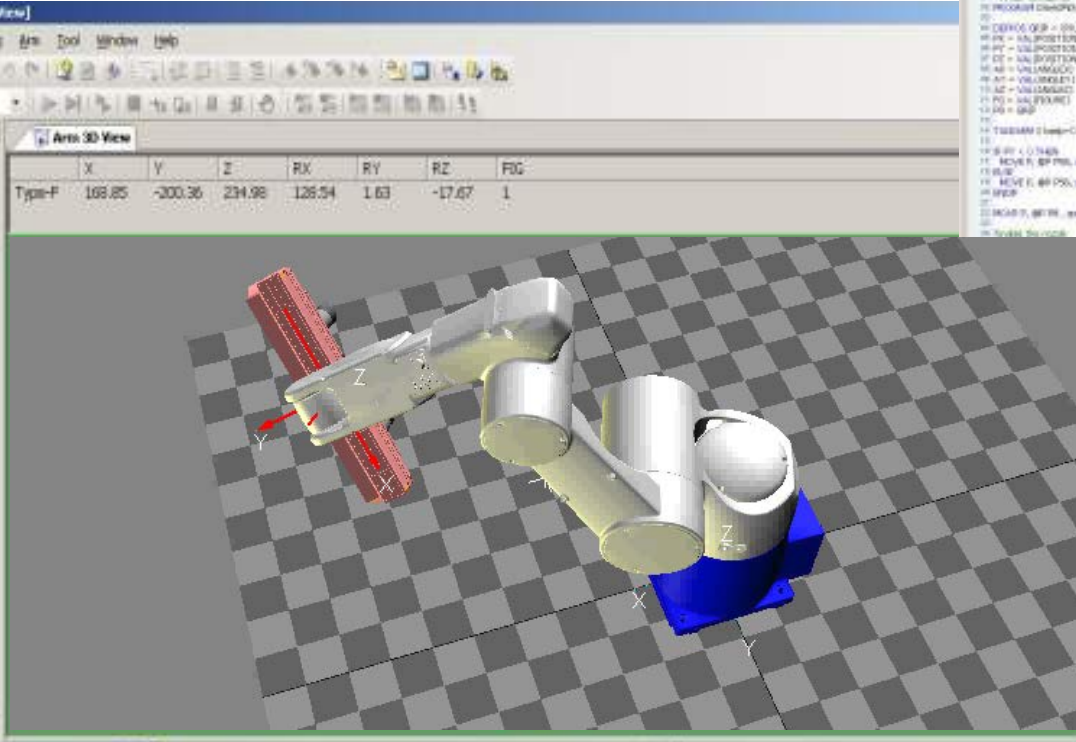
Program Editor

```

01 'TITLE "Reject_Lime"
02 PROGRAM Reject_Lime
03
04 #INCLUDE "hmi.h"
05
06 TAKEARM 0 keep=0
07
08 MOVE P, @E Rec_Pos, speed = Speed_Load
09
10 'open the gripper
11 SET IO[NOZZLE]
12
13 'Wait for 200 ms
14 DELAY 200
15
16 'close the gripper
17 RESET IO[NOZZLE]
18
19 END
20
21
    
```

Robot position

- 11:
- 12:
- 13:



Arm Player Plus

```

01 TITLE "Reject_Lime"
02 PROGRAM Reject_Lime
03
04 #INCLUDE "hmi.h"
05
06 TAKEARM 0 keep=0
07
08 MOVE P, @E Rec_Pos, speed = Speed_Load
09
10 'open the gripper
11 SET IO[NOZZLE]
12
13 'Wait for 200 ms
14 DELAY 200
15
16 'close the gripper
17 RESET IO[NOZZLE]
18
19 END
    
```

| No | Program name | File name | Title |
|----|-------------------------|-----------------------------|--------|
| 5 | Move_to_full_View_right | move_to_full_view_right.pac | Move_J |
| 6 | Read_next_Task | read_next_task.pac | Read_J |
| 7 | MOVE_TO_NEAR_VIEW | move_to_near_view.pac | Move_J |
| 8 | DrivePick | drive2pick.pac | DriveZ |

| Jump | No | X | Y | Z | RX | RY | RZ |
|------|----|----------|----------|----------|-----------|-----------|--------|
| | 2 | 230.7626 | 12.48975 | 308.595 | -156.3279 | -28.99126 | 73.147 |
| | 3 | -0.015 | 0.167 | -0.076 | 0 | 0 | 0 |
| | 4 | 211.3616 | -309.344 | 167.0355 | -178.9107 | 0.5689448 | 7383 |

| Jump | No | Scale | Type | Usage | Macro |
|------|----|-------|--------------|-----------------------|-------|
| | 0 | | System input | Stop stop (all tasks) | SN1 |
| | 1 | | System input | Strobe signal | SN2 |
| | 2 | | System input | Data area bit 0 | SN3 |

Program Manager

Variable List

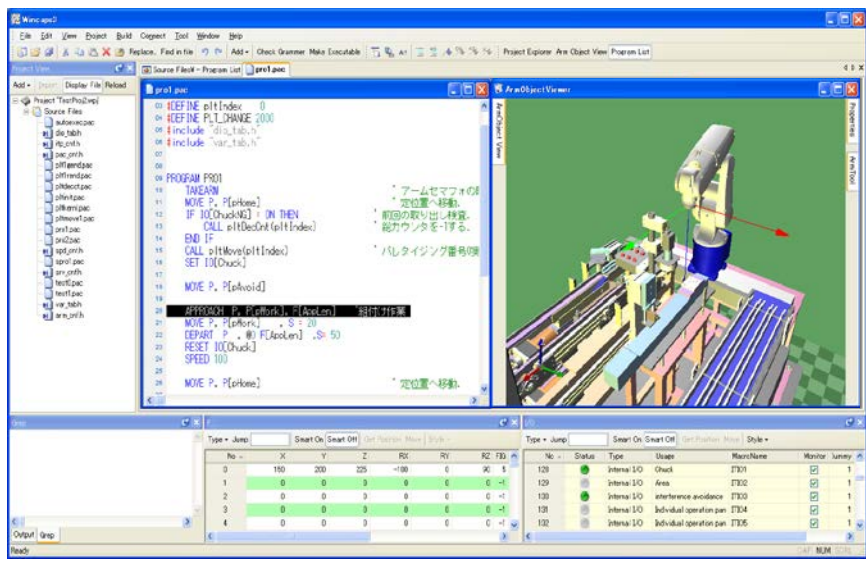
I/O Manager

AUTOMATICA 2008

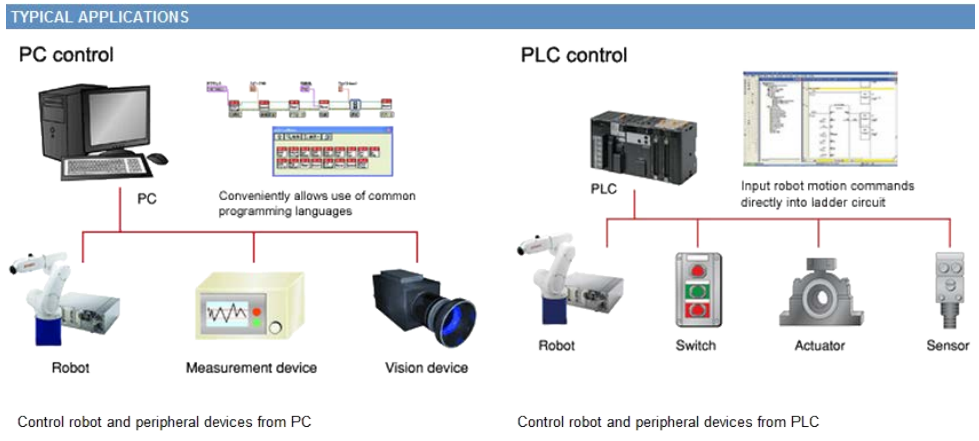
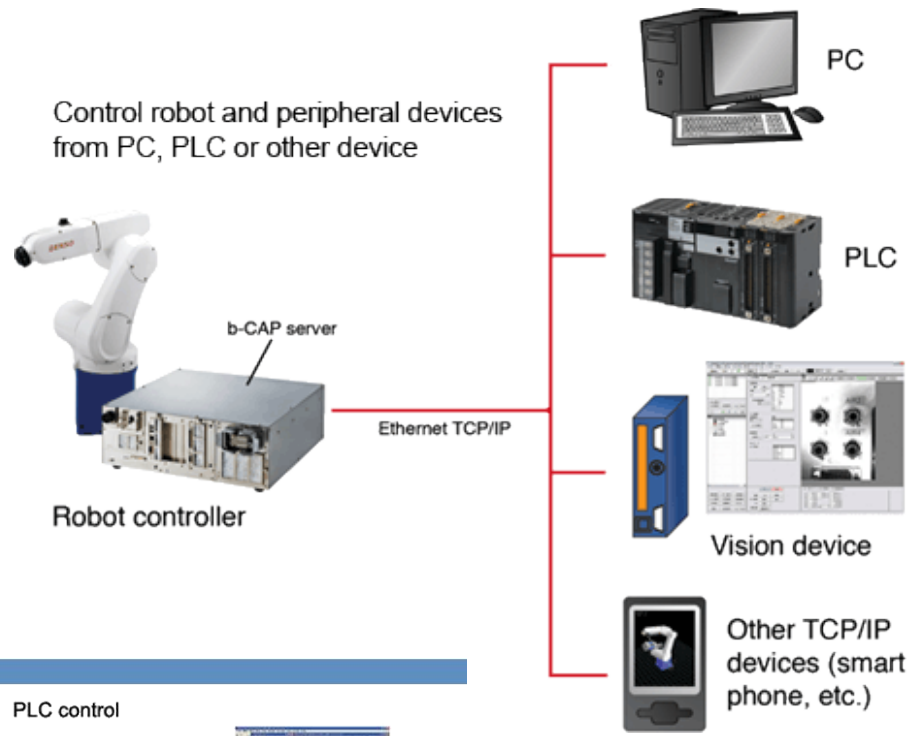
DENSO
DENSO WAVE

Sistema di Programmazione Off-line

WINCAPS III



- Convenient, direct control of robot and peripheral devices by PC, PLC or other devices using Ethernet TCP/IP instead of Teaching Pendant and PAC (DENSO programming language)
- Use of familiar interface and common programming languages reduces development time and cost
- New server mode enables higher-speed communication between the robot and control device



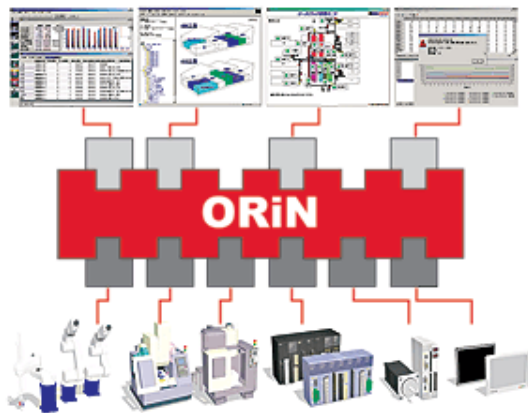
国際ロボット展 2011



- [Robot meets iPhone.mp4](#)

ORiN (Open Robot/Resource Interface Network) connects devices and application software to a network via independent interfaces. Applications can be easily created for devices from any manufacturer.

- Allows PC control of robots and peripheral devices
- Speeds up and reduces cost of development and integration
- Simplifies operation and maintenance
- Enables communication among devices from different vendors
- Allows overall system monitoring
- Uses common programming languages (Visual Basic® 6.0, Visual Basic® 2005, Visual C++ 6.0®, Visual C++ 2005®, Java, VBScript)

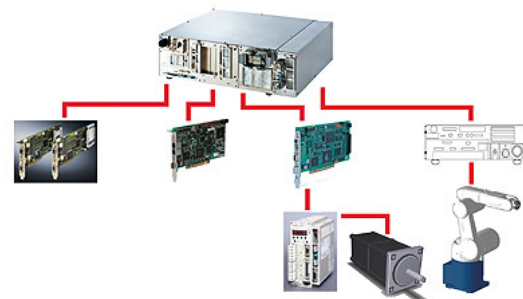


TYPICAL APPLICATIONS



Proprietary Tool (Bundle package)

For offline programming, data logging, variable monitoring, etc.



Semi-Embedded System (SDK or Runtime package)

For direct PC control of robot and peripheral devices via custom applications



Open System (SDK or Runtime package)

For large-scale monitoring of factory automation systems



- ORiN Vision is the extensive vision library designed exclusively for ORiN2 middleware. The library allows you to directly program robot vision applications with standard high-level languages including C++, C# and VB among others.
- ORiN Vision provides many functions for image capturing, image processing (like edge detection, filters, etc.), image analysis (like blob analysis, finding contours, etc.), image interpretation and also for robot and camera calibration. Because it combines ORiN2 and OpenCV the library allows you to directly program DENSO robots and vision applications with standard high-level languages including C++, C# and VB among others through only one interface.
- **Key advantages:**
 - Built-in processing functions use the OpenCV standard
 - High-level image processing functionality
 - The system is hardware independent allowing you to connect to any off-the-shelf camera regardless of interface (analogue, USB, IEE 2394, etc.)
 - Fast and efficient procedures result in short development times



THE FLEXIBLE STANDARD SOLUTION



ORiN VISION VISION LIBRARY FOR ORiN 2

| | |
|-----------------------------|---|
| AMBIENTE DI SVILUPPO | Adeguati linguaggi di programmazione (VB, C++, C#, etc.) |
| OPEN CV | Facile sviluppo di applicazioni di Robot Vision |
| COMPATIBILE | Con qualsiasi tipo di telecamera (analog / USB / IEEE1394, etc.) |
| ALL'OPERATORE | Non sono necessarie particolari conoscenze su operazioni Robot Vision |
| BREVI TEMPI | Di sviluppo |

www.densorobot.com

- HALCON software provides an integrated development environment (IDE) for machine vision and has become one of the worldwide industry standards.
- The HALCON Extension Package offers a complete and powerful solution with more than 1400 commands for operations including blob analysis, morphology, pattern matching, measuring, identification and 3D vision.
- Because HALCON is so widely used and highly regarded, DENSO has created a comprehensive, dedicated extension package to enable HALCON and DENSO users to conveniently program DENSO robots and control their vision applications through the same simple graphical interface.
- This integrated development environment, which is called HDevelop, is intended for engineers with a thorough knowledge of machine vision. With our DENSO extension package for HALCON users can program our robots easily.
- **Key advantages:**
 - DENSO robots can be programmed directly using one clear and practical interface
 - The DENSO extension package is conveniently and seamlessly incorporated into the HALCON integrated development environment, HDevelop
 - No previous experience of robotic programming is required

- Halcon extension package

- e.vision extension package

- Solidworks extension package

- Implementing a professional robotic solution is a substantial and serious project which can have a major impact on the whole of your business. Whether you are investing in a single arm, or a complete automated production facility, it is vital that you are confident in the potential performance of your installation.
- Visual Components® – the world's leading provider of 3D robotic and manufacturing software created 3DCreate® which is a simple, quick and cost-effective software tool that enables machine builders, system integrators and manufacturers to simulate complete factory layouts in a virtual environment.
- This highly innovative and powerful solution provides all of the functions you need to create new simulated components from existing 3D CAD data, allowing you to customise, observe and evaluate your industrial robotic applications in advance.
- **Key advantages:**
 - Use ready-made robot models from online eCatalogue
 - Easy plug'n'play interface for layout design
 - Integrate robot cells with factory layouts
 - Parametric components suit various customer cases
 - Connect to an external controller
- For more detailed information please visit: www.visualcomponents.com

- 3D manufacturing simulation and visualization

- **ROSY (Robot Optimization System) calibration kit for DENSO robots**
- Certain robotic tasks and applications require a level of precision and accuracy of pose that can only be achieved through more advanced methods of calibration.
- The ROSY (Robot Optimization System) calibration kit enables you to achieve these advanced levels of precision in a sophisticated, direct and straight forward manner.
- ROSY utilises a calibration sphere and cameras to assess kinetic errors. The resulting correction values are calculated and the control parameters can then be adjusted accordingly with a minimum of effort.
- **Key advantages:**
 - The user can increase the already exceptional accuracy of DENSO robots even further for special applications
 - The whole process can be accomplished easily and is usually completed in less than an hour
 - Identical and accurate robot cells can be created quickly and efficiently
 - On-site calibration service
- For more detailed information please visit: www.teconsult.de

- [ROSY.flv](#)
- [Robot Calibration with ROSY, EASY-ROB](#)

- Tracking

- IREX 2012

Esempi industriali



TrackViewer 1.2.1

Area Sovrapposta (%) **51**

Modalità di lavoro: Work

SAVE Actual IMG

Start Seq Stop Seq

Actual seq n: 0 OFF

Prodotto: Cucchiaino manico piatto

Ciclo Ispezione (ms): 676

443 OBjs in 00:02:03.01 OBjs/min 216.1 Reset

Obj: 0

| R1 Object | | |
|-----------|---------|---------|
| x | x | x |
| 57.3764 | 77.7739 | 164.014 |
| Y | Y | Y |
| 128.257 | 170.487 | 117.604 |
| Angle | Angle | Angle |
| 83.1715 | 116.369 | 4.21569 |

Obj: 0

| R2 Object | | |
|-----------|---------|---------|
| x | x | x |
| 132.983 | 77.2874 | 234.807 |
| Y | Y | Y |
| 156.794 | 89.4654 | 54.7118 |
| Angle | Angle | Angle |
| 120.249 | 83.345 | 109.563 |

Send

Oggetto destinato a Robot 1
Oggetto destinato a Robot 2
Già prelevato / non prelevabile

Sistema pronto Disco OK Robot 1 Com Robot 2 Com

Enable

Play next img n 13 di 16

SETTINGS EXIT [F10]

ImagingLab SRL
Consulenze e Prototipi:
Visione e Robotica
www.imaginglab.it - info@imaginglab.it

TrackViewer 1.2.1

Area Sovrapposta (%) **51**

Modalità di lavoro: **Work**

| R1 Object | | |
|-----------|---------|---------|
| x | x | x |
| 146.046 | 134.503 | 253.834 |
| y | y | y |
| 30.5348 | 154.81 | 171.32 |
| Angle | Angle | Angle |
| 83.5564 | 81.4666 | 73.5889 |

| R2 Object | | |
|-----------|---------|---------|
| x | x | x |
| 186.553 | 94.8434 | 28.688 |
| y | y | y |
| 70.0834 | 126.879 | 29.6785 |
| Angle | Angle | Angle |
| 246.512 | 54.4294 | 274.658 |

Oggetto destinato a Robot 1
Oggetto destinato a Robot 2
Già prelevato / non prelevabile

ImagingLab SRL
Consulenze e Prototipi:
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Sistema pronto **Disco OK** **Robot 1 Com** **Robot 2 Com**

Play next img n 6 di 11

Enable **SETTINGS** **EXIT [F10]**

Prodotto: **Siringa**

Ciclo Ispezione (ms) **437**

318 OBJs in 00:00:33.57 OBJs/min **568.2** Reset

- Proiettore fanale auto

- [DENSO Robotics - Robot performs vision inspection of PCB.mp4](#)

- High Speed Vision Inspection with Denso
6-Axis Articulated Robot

- Collettore Magneti Marelli.MTS

- Isole controllo vaschette

- Provini analisi urine

- Patreider

- Kern e cc

- Luxottica

Esempi speciali



The aim of this project is to add 2D vision to the BARMAN demonstrator shown in the figure. The BARMAN is composed of two DENSO robots. In its basic release it picks up bottles, uncorks them and places them on the rotating table. It then rotates the table, so that people can pick them up and drink.

The tasks of the Barman are summarized here:

- (i) to survey the foreground and check if empty glasses are present;
- (ii) to rotate the table and move glasses to the background;
- (iii) to monitor for a bottle on the conveyor, recognize it, pick it up, uncork it and fill the glasses;
- (iv) to rotate the table to move glasses to the foreground zone.

These simple operations require that suitable image processing is developed and validated. The software environment is the Halcon Library 9.0; the whole-project is developed in VB2005. The robot platform is the ORiN 2 (from DENSO).

- Robot Barman with machine vision

Look at the video to appreciate how 3D vision combined to a robot arm can increase the system flexibility in picking operations. The robot is a DENSO VS-6556G system. A laser slit is mounted close to the end effector, and scans the scene. Suitable 2D geometric Template Matching is used to get information on the scene.

3D raw data are segmented to interpret the scene, and to correctly pick objects up. The 3D optical head is formed by a CMOS B/W camera (1280x1024 resolution) and a lasiris laser projector, equipped with a cilindic lens, to form a light plane. The LabView graphic environment is used to develop the measurement procedures. The Robot motion libraries are developed by ImagingLab.

- Optolab Roboscan II

- DENSO Robotics - Robot serves ice cream

- DENSO VP-G2 six-axis articulated aseptic robot, controlled by National Instruments LabVIEW, inspects particle distribution of laboratory specimens.

- DENSO VS-Series six-axis articulated robot performs vision inspection of automotive parts with curved, reflective surfaces.

- Piegatura tovaglioli

- GrupoDCM Aplicacion Robots

- Roba - Tulipani

- [Academic Robot \(EN\)](#)

Un po' di pratica

Academic Robot + WincapsIII



DENSO

**Thank you for your
attention!**



K.L.A.IN.robotics

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DENSO

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