Industrial robots and their integration with vision systems

State of the art and future trends

DAY 1

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Senior Technical Manager
DENSO @K.L.A.IN robotics srl
Summary

- Introduction
  - K.L.A.IN. robotics
  - DENSO
- Software instruments
  - Presentation
  - Examples
- Conclusion and Q&A
K.L.A.IN. Robotics srl
KR structure

K.L.A.IN. robotics s.r.l.
Sede Leg.: Via F.lli Porcellaga, 3 - 25122 Brescia
Sede Amm./Op.: Via Caccamali, 67 - 25125 Brescia
PARTITA I.V.A. n° 03219670985
Tel. 030.35.82.154 - Fax 030.26.59.911
Core business

• K.L.A.IN. robotics, located in Brescia, is distributor for the Italian market and for Switzerland Italian market of two ranges of robots, which are complementary in the world of Factory Automation, and Mechatronics components.

• Denso, renowned Japanese producer, is the leader in the market of small assembly industrial robots, with SCARA Robot and Anthropomorphic; and Hyundai, renowned Korean producer, with Anthropomorphic robots up to 500 kg payload, specialized in welding, handling, enslavement.

• Our business is principally based on two fronts:
  - The first is the distribution of components for the Factory Automation to Systems Integrators specialized, operating in the realization of Assembly Lines and Special Machines of Handling and enslavement of operating machines in general, in fields such as cosmetic, medical the pharmaceutical, food, electronics, fashion, eyewear, quality control with or without imaging, plastic molding, etc. ..
  - The second is the Active Service, both with Training dedicated to the use of mechatronics products, as well as activities and support to customers or potential customers in the process of selection and / or development projects, or in the start-up of products already installed, in addition to verification of cycle times with simulations in the development Software.
<table>
<thead>
<tr>
<th>Model</th>
<th>HA006</th>
<th>HA010L</th>
<th>HA020</th>
<th>HH030L</th>
<th>HH050</th>
<th>HR050P</th>
<th>YS080</th>
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<th>HH100SL</th>
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<th>HS150L</th>
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<td>6 kg</td>
<td>10 kg</td>
<td>20 kg</td>
<td>30 kg</td>
<td>50 kg</td>
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<td>Max. Reach</td>
<td>1,394 mm</td>
<td>1,986 mm</td>
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<td>Degree of freedom</td>
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<table>
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<th>HS165C</th>
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<th>HS200</th>
<th>HS200S</th>
<th>HX200L</th>
<th>HX300</th>
<th>HX300L</th>
<th>HX400</th>
<th>HX400S</th>
<th>HX500</th>
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<td>400 kg</td>
<td>400 kg</td>
<td>500 kg</td>
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<tr>
<td>Max. Reach</td>
<td>3,128 mm</td>
<td>1,355 mm</td>
<td>866 mm</td>
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<td>3,090 mm</td>
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<td>3,090 mm</td>
<td>2,757 mm</td>
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<td>3,106 mm</td>
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</table>
DENSO Robotics

„Company & Product Introduction“

June 2011
DENSO Corporation

Founded 16 Dec. 1949

Net sales (April 1st, 2010 – March 31st, 2011)
Consolidated 37.7 bill. $

Employees (March 31st, 2011)
Consolidated Around 120 000
DENSO is the 2nd largest company within the Toyota Motor Group.
DENSO Corporation

**Engine Related Products**
- Engine management system,
- Electronically-controlled diesel system,
- Starter, Alternator, Radiator, etc.

**Climate Control Products**
- Automatic air conditioner, Car heater,
- Rear cooling unit, Compressor,
- Sensors, etc.

**Body Electronics Products**
- Instrument cluster, Windshield wiper
- Remote keyless entry system,
- IC flasher, Horn, etc.

**Driving Control and Safety**
- Antilock braking system, Traction control system,
- Cruise control system, Airbag sensing system,
- Vehicle stability control, etc.

08/05/2013 www.densorobotics-europe.com
DENSO EUROPE B.V.

Weesp, Netherlands (30 minutes away from Amsterdam Airport)

- Administration
- F & A
- Logistic
- Warehouse
  - Robots
  - Accessories
  - Spare parts
- Repair Center
  - Repair
  - Maintenance
DENSO Robotics

Moerfelden-Walldorf, Germany
(20 minutes away from Frankfurt Airport)

- Management / Marketing
- Sales Europe
- Order Handling
- SW + Application support
- Service & Support Hotline
- Application Laboratory
- Training
- ORiN2 Development & Support Center
- Stock for lease robots
DENSO. European Sales Network

Dealers in:
- Spain (CONTAVAL)
- Italy (Klain Robotics)
- Denmark and Sweden (AVN)
- Finland (EID Tech)
- Benelux (ROBA)
- UK and Ireland (AA Robotics)
- Turkey (iRob)
- Switzerland (Bachofen)

Middle East:
- Israel (PROBO-TEC)

Direct Sales in:
- Germany (Sales Office), Austria, and rest of Europe

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Cartesian Coordinate Robots

XYC4-G Series
Compact size cartesian coordinate robots!
Various choice for user’s needs
due to wide variations.
Integrated Compact Robots

XR-G series
Ideal for small systems; achieve compact systems with integrated compact robots

Applications
<Assembling & Handling>
- Compact
  - Reduced width of equipment and shortened production lines
- Lower Investment
  - Eliminate additional devices to lower cost

<Feeding & Carrier>
- Compact
  - Reduced width with ceiling mountable structure
- Flexibility
  - Programmable and flexible in feeding/conveying movements

40% reduction in footprint

20% reduction in facility investment

High speed
17% faster than our conventional Cartesian robots with combined move of coordinated slide and swivel motions.
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
DENSO RC7 Controller: Safety Cat 3

**Maintainability**
- One type controller can be connected with all robot arm
- Safety Circuit
- Mode Select Key
- Dual channel
- EMG STOP Circuit
- Monitoring Circuit
- Category 4
- Safety Box
- Lock out

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

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

**Usability**
- Panel Designer for Windows

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www.densorobotics-europe.com
• DENSO Automatica 2012 - RC8
Instruments
SW instruments

- **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
Wincaps III: OLP software

- 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.
Wincaps III (ORiN Solution)

Program Editor

Arm Player Plus

Program Manager

Variable List

I/O Manager

08/05/2013

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Wincaps III (ORiN Solution)

- DENSO HS pick and place simulation 2.35 sec.avi
- DENSO Robotics - 3-D simulation software
- Academic Robot (EN) - HD version
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
- **DENSO WincapsIII meets LabView on ORiN2**
- **Academic Robot (ITA) - HD version**
b-CAP: eth TCP/IP control protocol

- 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

Flexibility【リアルタイムコントロール】
マイクロコントローラRC8

Linux PCが2台のロボットの軌道生成を作る

レール下面に取付けたセンサーが車の位置、速度をPCへ送信
What can we do?

- **DENSO Robotics - Robots lay out slot-car track**
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 throw 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
ORiN vision

THE FLEXIBLE STANDARD SOLUTION

ORiN Vision

ORiN VISION VISION LIBRARY FOR ORiN 2

<table>
<thead>
<tr>
<th>AMBIENTE DI SVILUPPO</th>
<th>Adeguate linguaggi di programmazione (C, C++, OI, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPEN CV</td>
<td>Facile sviluppo di applicazioni di Robot Vision</td>
</tr>
<tr>
<td>COMPATIBILE</td>
<td>Con qualsiasi tipo di telecomando (analog/USB/IEEE1394, etc.)</td>
</tr>
<tr>
<td>ALL'OPERATORE</td>
<td>Non sono necessarie particolari conoscenze su operazioni Robot Vision</td>
</tr>
<tr>
<td>SIRENI TEMPI</td>
<td>Di sviluppo</td>
</tr>
</tbody>
</table>

www.densorobotics-europe.com
Halcon extension package

- 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
DENSO Robot

Support software for robot operation and maintenance
Strumenti di diagnostica e assistenza per Robot DENSO

Robot Tools

- Strumenti di sistema per ORiN2 -
Robot Tools supporta la diagnostica giornaliera ed ottimizza i costi di utilizzo dei robot.

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

Please check the similarity value, and modify the threshold value. That case is caused by the threshold setting. For example, when the value of TriMatchTemplate is below the threshold, it returns E_FAIL.

Please check the similarity value, and modify the threshold value. That case is caused by the threshold setting. For example, when the value of TriMatchTemplate is below the threshold, it returns E_FAIL.
Funzioni del Mobile Monitor

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**

- **Storia dei dati del Control log**
- **Grafica del Control log**
- **Start del Log Analyzer**
- **PAC registrazione dell’esecuzione programma**

**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

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

Mobile Monitor

DENSO Robot

Easy Backup

Control Log Analyzer
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
<table>
<thead>
<tr>
<th>Product name</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>GP Operator NEW</td>
<td>Connect your PC to a robot controller. You can operate a robot with a mouse/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.</td>
</tr>
<tr>
<td>Image Logger</td>
<td>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.</td>
</tr>
<tr>
<td>Virtual TP</td>
<td>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.</td>
</tr>
<tr>
<td>Control Log Analyzer</td>
<td>Obtains Control Log from a designated controller and analyzes the robot operating status by graphing out the Control Log: visualizes the operating status.</td>
</tr>
<tr>
<td>Easy Backup</td>
<td>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.</td>
</tr>
<tr>
<td>Mobile Monitor</td>
<td>Monitors controllers operating status and notifies errors or troubles through portable devices to an operator even not at the site.</td>
</tr>
</tbody>
</table>
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](http://www.visualcomponents.com)
• Visual Components Robot Simulation with DENSO WAVE "WINCAPS3"
• Visual Components Robot Simulation with DENSO WAVE "WINCAPS3" Part2
Premessa: Ripetibilità vs. Accuratezza

- La griglia rappresenta l’insieme delle posizioni raggiungibili cioè la risoluzione spaziale.
- La posizione insegnata è quella presa sul campo che viene memorizzata come variabili di giunto.
- L’errore di posizionamento dipende dall’accuratezza del modello cinematico.
- L’accuratezza del modello cinematico dipende da parametri geometrici (tolleranze) cedevolezza, etc.
- È più facile costruire robot ripetibili piuttosto che robot accurati.
Esistono diversi modi per risolvere semplicemente questo punto:

- Eseguire una adeguata calibrazione tra isola reale e isola virtuale
- Usare robot detti “high accuracy robot”
- Usare strumenti che correggono le discrepanze tra virtuale e reale direttamente durante il ciclo di lavoro (si pensi all’insegui giunto laser per isole di saldatura)
• **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 straightforward 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](http://www.teconsult.de)
• ROSY.flv
• Robot Calibration with ROSY, EASY-ROB
Industrial Examples
1. Basic Idea

2. Difference between the function with synchronous extended joints and the one with asynchronous extended joints

   - the function with asynchronous extended joints
     
     The revised position is calculated based on the Cartesian Coordinates.

   - the function with synchronous extended joints
     
     The revised position is calculated based on the Joint Angles.
     The teaching position is translated to joint angles, and the joint angles are treated as the target angles.

3. How to use the FIGCHECK.MAX_DISPLACEMENT_dJ in cOrbitGenSync.ini

   In case of the function with synchronous extended joints

   This parameters are used as the limited angles for the difference between the teaching joint angle and the revised joint angle, in order to check the error of the convergence algorithm.
   Therefore, if the parameters are larger, then the error will not cause.
   REQUEST: After the parameters are larger, check the motion in the WINCAPS3
• DENSO Robotics - Robot performs vision inspection
Special Examples
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
• **Folding napkins**
Thank you for your attention!