The Man and the Robot: Italian and Japanese Approaches

Educating to Service Robotics

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Summary

- Introduction and motivation
- Educating the potential users
- Educating the future engineers
- Educating the researchers
- Conclusions

Difficult Adoption of Service Robotics

- Service Robots will undoubtely become a new market and will potentially force great changes in our societies.
- However, to make the transition fast and as little traumatic as possible, we need to prepare users, developers and manufacturers, and create a suitable infrastructure to support this technology.

Motivation to Targeted Education

- However, cultural and geographical factors may slow, if not hamper, this process of development and introduction of the new technology.
- In Italy, for example:
  - diffidence towards new technologies may make it difficult to introduce service robotics,
  - local cultural differences among regions and cities require to develop approaches specific to each audience,
  - Small Universities do not have resources and industrial access as more famous and established ones have.

The Case of the Italian North East

- Italian society has very strong local characteristics
- Approaches working in one region (or in one city) may not work in nearby communties because of different cultural background. For example
  - The Italian North-East is considered a model of development and success of very small and small companies.
  - Typical cities in this area have 10's of thousand small (less than five employees) enterprises
  - Enterprise success is based on hard work, low labour cost and process innovation, not on product innovation
  - Family run enterprises hamper generational change, introduction of professional management, and openness to innovative thinking.
  - There is a lack of working partnership with universities
  - Return time on investment must be very short
  - Investments in R&D are very small

What to do?

- How to solve this seemingling impossible problem?
- One possible (perhaps the only one) approach is Education:
  - Educating companies to the need of new products to avoid obsolescence and death and teaming up with other companies and universities
  - Leveraging on every funding opportunities to start a dialogue with the industrial world
  - Educating researchers to understand company needs
  - Educating potential users on the advantages of new products
  - Creating and educating the support workforce

Result: create a virtuous loop that will spur local economy and research

Educating Companies: a Partnership Example

- Between: University of Verona and **GSK (GlaxoSmithKline UK)** (a typical small company in my home town Verona!)
- Objective: robotization of sterile production lines
- Constraints:
  - Fast turn-around (18 month cycles)
  - Economic viability at all phases
  - Satisfying industrial standard and regulations
  - Ready to be transfered to sister plants at alternate cycles
- Other (hopefully) Examples: city car, airport security, humanitarian demining, service robotics (home automation).

Background and Motivation

- Pharmaceutical Industries aim at reducing as much as possible human intervention in clean rooms. Sterility may be lost and production must stop for a significant amount of time.
- Human intervention is needed when equipment breaks down, for regular maintenance, change of production, or environment assessment.
- These functions should be carried out by advanced robotic tools capable of replacing Humans in Sterile Room operations.

Approach to Solution

- We proposed a development consisting of three phases addressing the following systems:
  1. Warehouse robots
  2. Supply robots
  3. Maintenance robots
- Each phase must have independent technical and economical value
- Robotic devices must be put immediately into Company's operation
- Business, and not research, approach

Project Goals

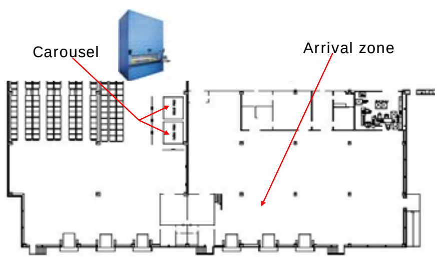
- Pharmaceutical Industries foresee a large increase in small size lot production which would be better handled by automatic systems.
- A small transport robot would avoid major interventions in existing plants, and could be integrated in existing procedures.
- Thus the need for a **Proof of Concept** of an autonomous transport storage operator for small parcels.
- This demonstration will be implemented in the **Parma GSK warehouse**.

Proof of Concept

- Procedure and Operation Analysis
- Functional Definition (storage tasks)
- User's Requirements Collection
- Economical Justification
- Implementation Challenges
- Two Step Implementation
  - Proof of Concept
  - Industrialization

Robot Navigation Requirements

Navigation will be initially simulated in the ALTAIR Robotics laboratory, to verify the feasibility of using the robotic system in GSK warehouse.



Main Robot Tasks

- The robot we used is a commercial Neobotix mobile platform, equipped with a custom arm, which moves autonomously in a crowded environment and handles packages.
- Target task is parcel transfer (< 40 cm X 40 cm X 23 cm, ≈ 20 Kg)
- Parcel identification:
  - *Instruction sheets*. They are mostly (up to 90%) shipped in pallets.
  - *Returned materials*. They are carried from the production areas to the warehouse.
  - *Labels*. Parma receives about 5000 lots, 70% of which in small parcels.

User Requirements

- **Manipulation**
  - – Working area requirements
  - – Payload dimensions and masses
  - – Dexterous manipulator
  - – Custom gripper
- **Mobile Base Motion**
  - – Medium length navigation
  - – Crowded, dynamic and unstructured environment
  - – Robustness to errors in sensing and to varying environment conditions
- **Environment**
  - – Objects dimensions and positions in the simulated environment

Economical Justification

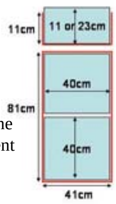
- During 2001, the flow of small parcels was:
  - Material transfers N.2756
  - Shipments of labels N. 10,000
- Example: November 2001, 10656 transfers of which:
  - Small parcel to QC N. 476
  - Small parcels to vertical storage N. 112
  - Small parcels to production N. 100.
- Average operator time to store a small parcel is 4 minutes.
- 40,000 minute/year handling small parcels are about 700 work-hours, approximately a Full Time Equivalent (FTE) that could be saved by a robot.
- Dead times and set up time (4 minute/parcel), the time saved will be closer to two FTE per year

Implementation Challenges

Work with an industry implies a different way to plan the research work. In detail, some critical requirements are:

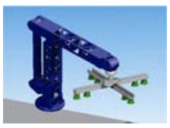
- Compliance of SW development to a coding standard, in order to satisfy validation tests
- Documentation to keep track of the project progresses, new versions...
- Strong standardization of each task, both in production and in design

Technical Challenges



- Robot navigation & localization in
  - Partially structured
  - Public
  - Dynamic environment

  using laser and sonar sensors, without impact on the exsisting environment, requires further development
- Map building and map updates
- Human Robot Interaction is still a controversial subject
- Light-weight arm development
- Custom Gripper design
- Minimal fault management:
  - Safety requirements



Expected Results

Benefits for the firm are related to:

- Increasing knowledge in a new technology
- Enhancing their technological culture
- Creating a competitive advantage
- Avoiding human intervention in critical tasks
- Acting now for future requirements
- More effective use of personnel

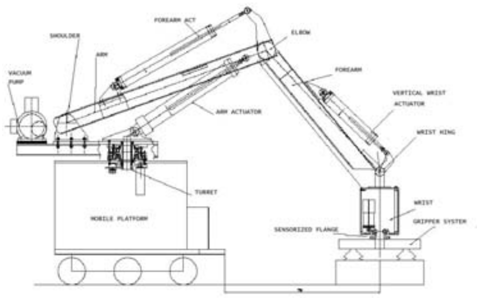
Project short term results:

- Prove the effectivness of the robotic system in light logistics tasks
- Transfer research technology to an industrial context

Project long term results:

- Robot integration with production lines
- Robotized sterile room maintenance

Technical Aspects: the Mobile Manipulator



The Mobile Manipulator

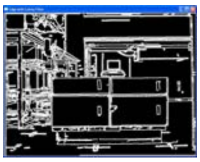
Mobile robot with integrated mechanical arm, equipped with the following sensors:

- TV camera
- Laser
- 8 ultrasound sensors
- Force sensor
- Bumper

Parcel Recognition

Consists of the following steps:

- Move the robot in front of the pallet and acquire an image
- Filter image and extract contours with Canny filter
- Identifies and groups contours
- Contours selection based on parcel model
- Pallet height is determined by the number of parcel extracted



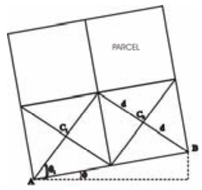
Computing Parcel Coordinates (1)

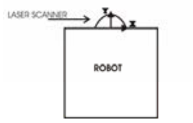
C_i is the centroid of the parcel (and the target point of the manipulation motion) refered to the platform reference system. ϑ is the angle by which the gripper must be rotated to grasp the parcel with the proper orientation.

$$\vartheta_1 = \pi / 4 + \vartheta$$

$$C_1 = (A_x + d\cos(\vartheta_1), A_y + d\sin(\vartheta_1))$$

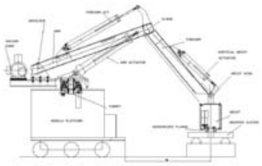
$$C_2 = (C_{1x} + 40\cos(\vartheta), C_{1y} + 40\sin(\vartheta))$$

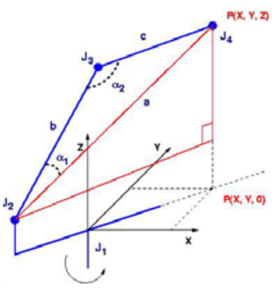




The Inverse Arm Kinematics

- The special structure of the robot simplifies the computation of the inverse kinematics.
- Inverse kinematics is solved with geometric consideration.

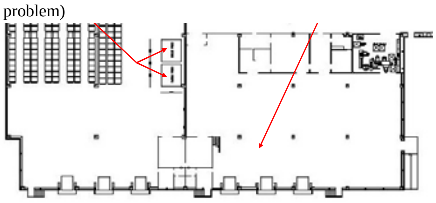




The Proof of Concept Demonstration

Lessons Learned

- Formal request to propose the industrialization of the prototype
- Project discontinued because:
  - Not included manufacturing partner in the first phase (cannot ask for more money to do again the same project)
  - Lack of full requirement analysis (even expert users don't know well their problem)



Educating Students: a Hands-on Approach

- Between: University of Verona and a number of high, middle and elementary schools in the Veneto and Trentino areas.
- In these areas, professional and vocational schools have a very large impact on local industries. Therefore objectives are:
  - Reduce diffidence towards technology
  - Form local technical and scientifical personnel
  - Avoid migration of technical capabilities to more industrialized areas
  - Insert technical personnel with advanced concepts into local companies and enhance their capabilites
  - Develop technical people with whom to form future partnerships

LEGO-Based Training courses and Internships

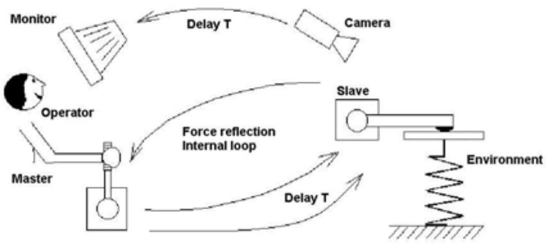
- **Focus on basic concepts: mathematics, physics, kinematics, reasoning, sensing and actuation, control.**
- **Goals:**
  - Make youngster approach sciences in a fearless manner.
  - Provide gender-independent scientific teaching
  - Develop partnership between High Schools and University
  - Market technical and scientific capabilities of smaller Universities
- **We train about 50 High School students a year (past two years)**
- **Started joint projects with 3 High Schools to make robotics education a year long affair**

LEGO Design Examples

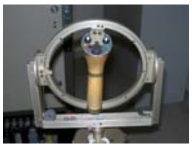
- Brief refresh course on basic math and physics
- Short course on kinematics
- Concepts of control
- Concept of planning
- 40 hours of frontal lectures
- Then students are asked to design, fabricate and test their own robot

LEGO Design Examples

Educating Students: Teleoperation Structure



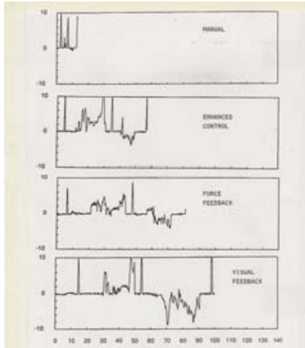
Educating Students: Teleoperation Basics



- Service robots will be essentially teleoperated thus this technology must be taught from the very beginning
- We develop and test complex teleoperation systems to implement and test new algorithms and capabilities
- Using high performance devices

Educating Students: Teleoperation Technologies

- Software architectures (Penelope)
- Time delay compensation
- Data packet loss compensation
- Teleoperation algorithms development
- Property measurements



Educating Students: Teleoperation Systems

Collegamento a DSCN0021.lnk

- Test bench for performance measurements
- Full 6-DOF Froce Reflectign teleopration with FPGA control

Collegamento (2) a film1[1].lnk

Collegamento (2) a film5[1].lnk

Educating Students:

Elementary Schools

Lessons Learnt

- Dialogue difficulties between Schools and University Faculties
- Enormous lack of fundings
- Lack of local support from Institutions and Foundations
- Need of innovative ideas for curricula and laboratories to attract students of the MTV generations
- Huge potential for collaboration and for exciting results!!

ALTAIR

Thanks for Your attention!

Conclusions

• In the difficult moment of the Italian economy we need to learn how to make innovation networks among all stakeholders: Universities, Manufacturers, Enterpreneurs, Schools and Users.

• We need to overcome strong individual and local myopic views to promote a more open approach to technology development.

• In certain parts of Italy, Universities must be the leaders in this process, since political, economic and industrial forces are sadly failing to provide leadership.

• Universities must overcome their “ivory tower” approach to research and address directly the problems surrounding them.

• We need very large doses of patience to carry out these tasks!!