Competitiveness in Emerging Robot Technologies (CEROBOT)

The opportunities in safety and robots for SMEs

Theme 2: The new paradigm in robotics safety

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Safety problems with robots

• Fear of robots is deeply rooted

• Separation of humans and robots has been the traditional approach
  • Physical separation with robots in work cells
  • Use of sensors
  • But accidents can happen - eg in training, maintenance

• A new paradigm is needed if we are to better exploit robotics

• Learning from other sectors - automobiles, sport
  • Attitudes to risk
  • Analysis of accidents
  • Minimizing effects of impacts
Regulatory framework - standards, directives

- The safety question depends crucially on definition of robots
- The cornerstone of safety in the workplace has been human-robot separation
- Safety standards grew out of industrial machinery standards & product safety
- Desire for different ways of working is sparking new perspectives on safety regulation

- Japan's Ministry of Trade and Industry (May 2006) announced a first set of safety guidelines for home and office robots - now required to:
  - Have sensors to help them avoid collisions with humans
  - Be made from soft and light materials to minimise harm if a collision does occur
  - Have an emergency shut-off button.

- New views arriving - ISO 10218 Part 2 - for more interaction with humans

- EU has to work in international fora to agree standards
The staged programme for safety design and build

1. **Build Robot units with Safety features**
2. **Analyse naked site for Safety:**
   - Audit hazards
   - Risk analysis
   - Risk register
   - Mitigations design
3. **Analyse completed system design (CAD) for Safety:**
   - Audit hazards
   - Risk analysis
   - Risk register
   - Mitigations design
   - Operational procedures
4. **Create test safety procedures:**
   - Safety systems testing on-site with robotics
5. **Install safety systems, and integrate with robot and auxiliary systems**
6. **Active operational procedures for safety**
Generic simplified value chain for today’s safety systems

Customer site installation

Factory production of safety system

- R&D
- IPR
- Manufacture

Specialised Safety Components

System assembly, Test & packaging

Marketing

After sales

- Safety Systems Design:
  - Hazard audit
  - Risk assessment
  - Safety design

Systems Integration & Programming

Test and correct

After sales

Factory installation of safety systems in robots during manufacture

Externally produced components

For: - Sensors
- Actuators/End effectors
- Power/utility systems
- Control, communications and coordination systems

Bought-in components manufacture

- R&D
- IPR
- Manufacture
- Marketing
- After sales
Market potential for traditional robotics safety in the EU

- Market size in traditional robotic safety products and services is unclear - no complete picture of all types of sales falling into category

- Take into account:
  - component systems (e.g., light curtains, PLCs, sensors, actuators, interlocks, safety buses, vision systems etc)
  - also their integration into a complete safety environment

- Systems integration value - can be greater than the physical component value

- Safety segment estimated at 10-15% of a total installation costs for both products and services is of the order of €1.4 to 2.1 billion per year
Human-robot Interaction will change radically

- The next generation of robots will be able to safely interact with people directly
- Traditional vs new safety approach
- Making a rigid, heavy robot to behave gently and safely is difficult
- Rethink how robots are designed and function - for a completely safe robot, with new safety standards - now evolving fast

- Domains for direct interaction with humans:
  - Helping humans in heavy and light industrial/agricultural jobs across many sectors
- Longer term:
  - Medical care - hospitals, rehabilitation, etc
  - Other professional services
  - Support for elderly care
New directions in robot safety: robotics for co-working
1. The collision avoidance approach:

Virtual protective shields around human operator

Source: SMErobot project Datasheet, Collision Avoidance, 2008
The new approach - analysis of head injury from robot arm

New directions in robot safety - robotics for co-working

2. Lightweight soft robots with non-rigid limbs

- Design for intrinsic safety - human safety is guaranteed by the physical structure itself and not by external protecting sensors or algorithms

- This type of safety means ensuring no accidents occur, even with a failure in the robot - programming bugs, sensor glitches, hardware, etc

- Requires rethinking of: actuators and variable rigidity; dependable supervision and planning algorithms; control algorithms, for safe human-robot physical interactions

Prototype Variable Stiffness Actuator (VSA) controls robot arm with 2 motors.

Just like human and animal muscles - move in opposite directions to move limbs

Motors move antagonistically to manipulate non-linear spring, an elastic transmission between each of the motors and the moving arm. EU FP-6 PHRIENDS project, 2007
Conventional industrial robots
- Accepted, fully working
- Make up the vast majority
- Isolated in workcells
- Saturated market (auto in decline)

Humanoid service robots
- Emerging still
- Fairly static last 30 years
- Should mix with humans safely
- Sensor and actuator advances rather than cognitive processing

Co-working, shared environment, high safety, soft, lightweight
- Concept to early emerging stage
- Should mix with humans safely
- High market potential (SMEs)

Mobile robots
- Taking hold in domestic service eg vacuum cleaners and in industrial service eg forklift trucks
- Often simple, mono-function
- Domestic types should mix with humans safely

The safe soft SME robot forms a weak point of discontinuity
The safe soft SME robot in the cost/production volume curve
Relative cost per unit, nominal price
Possible emergence of the SME and soft robot applications market

**SME robot -1**

Sales to SMEs in:
- Industrial manufacturing
- Food processing
- Agriculture
- Health care and elderly care

**Industrial robots**

Sales to:
- Large enterprises
- Industrial manufacturing SMEs

**SME robot- 2: enhanced cognitive Processing, & sensing (vision/ audio/ comms)**

1. Sales to SMEs in:
   - Industrial manufacturing
   - Food processing
   - Agriculture
   - Health care and elderly care
   - Service sector

2. Domestic (consumer) sales