Applying STAMP on Safety Standards of domestic robots

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Are Domestic Robots Safe Enough?

TECHNICAL FACTORS
- Physical
- Software
- Hardware

NON TECHNICAL ASPECTS
- Mental Models
- Cultural
- Social

STAMP
STANDARDIZATION
Domestic Robotics

MECHATRONIC SYSTEM

ANTHROPIC ENVIRONMENT

Space
Vision Height
Working Height
Power

STAMP
Powerful Hazard Analysis Technique

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Classification of Domestic Robots ISO 8373 - Taxonomy

Robots and Robot systems

Industrial Robots
- Fixed base /Mobile

Service Robots
- Domestic Robots
  - Security
  - Collaborative
  - Edutainment

Other applications: e.g. Military

Personal
- Pet-type robots
- Partner type
- Communication
- Care robots

Collaborative
- Vacuum Cleaners
- Pool Cleaning
- Window Cleaning
- Lawn Mowing
- Ironing

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Traditional Safety & Reliability Engineering Analysis

- Task Analysis
- Energy Barrier
- Risk Tree
- Subsystem Analysis
- Forward Chain of Events
- Risk Tree Analysis
- Fault Tree Analysis
- Failure mode and effect analysis
STAMP

Accidents
Level of Severity
High Level System Hazards
Hierarchical Control Structure
Safety Design constraints
Responsibility to the user
Environmental Assumptions
Identify the accidents

A1. Injury or damage by jagged edges or corners.
A2. An actuator is stroked by arbitrary object.
A3. A component may explode.
A4. A resident pinched between arm-wall-object.
A5. Body’s part caught in an uncovered actuator.
A6. Robot run on a person or another home asset.
A7. Electrical shock.
A8. Contact with worn insulation.
A9. Uncontrolled chemical/ fire factors.
A12. Irritant / sensitizing effects.
A13. Interference causes injury or equipment damage.
Assign a level of severity

- **LEVEL 1**: Loss of life / serious injury
- **LEVEL 2**: Damage / Injury
- **LEVEL 3**: Damage / Minor injury

**SERIOUSNESS OF HAZARD**

Risk Assessment
Assign a level of severity

**HIGH LEVEL SYSTEM HAZARDS**

- **ELECTRICAL**
- **SLIPPING, TRIPPING & FALLING**
- **MECHANICAL**
- **RADIATION**
- **ERGONOMIC PRINCIPLES**
- **MATERIALS & SUBSTANCES**
- **ENVIRONMENTAL**

**ISO 12100-1,-2 (2003)**
High Level System Hazards

- High Level System Hazards
  - Environmental
  - Materials & Substances
  - Ergonomic Principles
  - Radiation
  - Slipping, Tripping & Falling
  - Mechanical
  - Electrical
  - Radiation
  - Ergonomic Principles
  - Materials & Substances
  - Environmental

A7, A8, A1, A2, A3, A5, A11, A4, A6, A10, A13, A12, A9

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Cushioning shall minimize cutting, stabbing, shearing.

Sharp edges, corners and picks shall be avoided. Soft material shall be used for covering.

Label signs on stored energy sources to avoid pressing an inappropriate switch.

Replace mechanisms if they work under heavy load.
No additional clothing.

Nickel & Chromium substances --> Appropriate info.

Surfaces & Covers free from loose chipping or peeling paint.

No flammable dust, toxic vapours, paint thinner, oil based paint, ammonia, drain cleaner, chlorine bleach.
Screws & Fixtures against signals / connectors.
Homogeneous network of multiple sensors adequate to its task.
Design connectors against separation of wires.
Prevent cords from coming in contact with burrs, cooling fans.
Internal connectors must be waterproof and give a reliable connection.
Inspect cables for frays.

Panel covers and cable cross-section.

The electrical equipment should follow the relevant requirements.

Install emergency buttons & tactile sensors which halt all mechanisms in case of danger.
3 types of emergency stops + remote + passive infrared sensors should be installed. Red functional tested and well maintained (regular test and calibration).
Check repeatability, settings and reliability.
Find bugs in program
Faulty mechanics or installation
Mechanical stops or shock absorbers.
The restart method must be tested that deals for all malfunctions. A more detailed method than a simple button.
Must not restart after 5 seconds.
Provide a known safe point for restart.
Robot movements shall be as smooth as reasonably practical, given the appropriate task goals of the robot.

Supplementary use of inherently anti-noise components e.g. foam, baffles, curtains, coatings to protect hearing.

Use of active sound absorbing mechanisms to avoid emitting noise.
Disorientation must be avoided. The frequency of signal must not interfere other robots or devices. The robot must not respond to other signals like light wavelengths, acoustic frequencies, background noise frequencies for audio signals. It must respond to remote controller. Robot's tasking path shall not be affected by adjacent metal robot's equipment, hidden cables, another device using frequency within the same range.
Assign responsibility to the user for safety-critical actions

- Operate the robot scheduled times every day.
- Air-openings opened.
- Don't expose it to high temperatures.

- Don't allow humidity to mutilate it.
- Close the door of balcony.
- User must recognise variations of audible signals such as indicators.

- Operate it away from candles embers, distilled alcohol, gasoline, thinner, ashtrays with burning cigarettes.
Assign responsibility to the user for safety-critical actions

- User should be advised how to perform regular test and maintenance of electrical equipment.

- User must not remove, bend, cut weld electrical or electronic parts inside the chassis.
- The power cords must be uneven, without irregular corners. Cut continuous loop.

- Keep cords in good condition, maintain regular. Make sure they are carrying the right current capacity at the label.
- Attach cords in the wall using tape.
Assign responsibility to the user for safety-critical actions

- User should pay extra attention to symbols indicating ON/OFF, wear protective clothes, caution/danger/attention notes, tips and hints.

- Warning symbols show a possibly dangerous electrical condition.

- Manual should bear figures and steps in order to make clear the installation, guidance for packing, unpacking, preparation, software, beacons, console and charging station, installation of wires, remote control.
Assign responsibility to the user for safety-critical actions

- Place the robot away from sources with bright sunlight, fluorescence and electronically dimmed lightning.
- User shall be informed for the spectrum and frequencies that causes interference.
- Don’t use two or more same robots in case they interfere one another (infrared sensors).
- Jamming devices like infrared LEDs that may saturate infrared sensors are not allowed in the same area.
Assign responsibility to the user for safety-critical actions

- User should retain the safety and operating instructions of the manual for future reference.
- User must not try to repair any tools or components while it is executing.
- User must be informed about maintenance requirements.
- If it starts vibrating he should call the authorised personnel.
- The user should recognise the number and name of the device for identification that should be easily readable and displayed.
Assign responsibility to the user for safety-critical actions

- User must inform unaware residents about hazards caused by improper handling of device, of supplementary tools, or thrown objects such as cuts, burns, eye injuries or soft tissue damage.

- A robot must not be turned in the direction of the people, pets, homes, streets, or automobiles where parameters of domestic tasks are changing.

- The operational area must not be overcrowded with infants, children, passengers, disabled, neighbours, guests, elderly or pets in case that the robot contains harmful tools or accessories.
Assign responsibility to the user for safety-critical actions

- User must not spoil, mutilate, burn up or incinerate the battery as it will explode.
- Charge in dry well-ventilated area where the temperature is moderate.

- Specific responsibilities for maintenance should be assigned to the user.
- User must inspect cables for frays.
- User must not use a damaged cord.

• Specific responsibilities for maintenance should be assigned to the user.
Standardization and Machine safety...

**Machine Safety Compliance and Enforcement Comparisons**

**European Model**
- Machinery Directive
  - (Listed Current Standards for Compliance)
- TYPE A
  - Basic design guidelines and basic terminology for machinery
- TYPE B
  - EN Standards
  - General safety aspects
  - Reference to special protective devices
- TYPE C
  - Specific safety features for individual machinery groups

**Enforcement**
1. Original Equipment Manufacturer (OEM)
2. Engineering Firm
3. End User (as supplier for modifications)

**USA Model**
- OSHA
  - Listed Regulations from the 1970’s
  - “Right to Reference”

**End User**
- Both - New, Re-built, Modified, & Legacy Machines

**Liability:**
- OEM
- Engrg. Firm
- End User (as supplier)

*JB Titus & Associates, Control Engineering*
Standardization and STAMP model…
Benefits of STAMP on standardization

A System's Approach

- Control Hazards
- Estimate the System
- Enforce Constraints in the design level
- Recognise the weak points

Social
Ethical
Legal

SOCIOTECHNICAL DIAGRAM

SAFETY-DRIVEN DESIGN

Structured Way

Standardization

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Thank you for your attention!

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