Appendix to:

"Robotic Visions to 2020 and beyond – The Strategic Research Agenda for robotics in Europe, 07/2009"

Glossary

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"Robotic Visions to 2020 and beyond – The Strategic Research Agenda for robotics in Europe, 07/2009" can be obtained from:

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CARE
Coordination Action for Robotics in Europe

1. Actuation:

Techniques which generate forces and torques to thereby manage the motion of robots.

Examples:

- Electric motor
- Fluid actuators
- Air muscles
- Hydraulic power transmission
- Piezo-electric actuator
- Ultra-sonic motor

2. Adaptation:

Adaption is a change to the process or the method of execution by the system itself. It is generally performed during run-time, changing the system according to different factors. Adaptation does not necessarily involve cognitive decision making even if it is often strictly correlated. Adaptation can take place over different timescales, e.g. adaptation to wear and tear, or long term changes in a user's needs (→ slow adaptation); sudden changes in environmental conditions such as switching on the light in the proximity of a vision sensor (→ fast adaptation).

Examples:

- Hardware (platform, work cell, robot, and controller of motor) can adjust to the internal changes in the system
- Hardware can adapt according to wear of e.g., the gear box.
- A system can adjust to the process or the user.
- Adaptation can be carried out as a result of changes in the environment, product geometries or materials, user, process quality feedback or multi-use processes.
- Adjusting the process based on timely external instruction, but not through pre-defined alternative program flow, e.g. several different parts being produced on one productionline in random order.

3. Autonomy:

Autonomy is the ability to perform a task, a process or a system adjustment through the system itself without human intervention during the process. This also includes the capacity to judge an actuation and decide what to do on your own, which implies some degree of responsibility. Autonomy enables robots to perform in dynamic environments. The level of autonomy can be assessed by defining the necessary degree of human intervention. In distinction to automatic where there is a reaction to sensor data, with autonomy the system senses externally to itself.

Examples:

- Automatic assignment of tasks from high-level instructions established by a user to facilitate the operation.
- The robot can be autonomous without cognition, e.g. interpreting the environment.
- A system can be autonomous without adapting, but many autonomous systems will also be adaptive nevertheless adaptation is not a requirement for autonomy.
- A robot which does different tasks or decides to complete tasks in a different order is autonomous.
- A robot that is being told to pick up a bottle from the table is autonomous during the process of picking up the bottle but then stops being autonomous.

- The following require a certain level of autonomy: situation awareness by assessing the internal state and the environment, planning of a mission, task or path, decision making, adapting actions to reach a goal, developing own strategies and rules.
- Automatic assignment of tasks from high-level instructions established by a user to facilitate the operation.

4. Calibration:

Examples of calibration are:

- setting equipment to a standard measure
- ensuring accuracy of operation
- registration of objects
- operation to permit software
- mechanical referencing of parts
- identification of internal and external parameters of a sensor, actuator and their interfaces

5. Cognition:

The processes of reasoning, perception, planning and learning based upon internal representations of the external world which are analogous to apparent processes in the minds of humans and animals. Cognitive skills are used to enable the robots to reason, act and perceive in changing, partially known, and unpredictable environments in a human-like and comprehensive manner.

6. Collision Avoidance:

Collision avoidance is the capability to avoid a physical contact with objects and subjects in the working environment of robots. This can also include the aspect of self-collision avoidance.

7. Configuration:

Configuration is a change to the robot or to the larger system which is performed by the operator when the system is not in operational mode both at the beginning of and during the lifecycle of a robot.

Examples:

- Configuration is done mainly through instruction: by task or mission description (given by the user), by demonstration (lead-through by the user), by imitation (robot is learning by observing the user)
- Programming can be considered as a kind of system configuration taking place as text-based, graphical or teach-in.
- Configuration is usually needed during the commissioning phase of a robot system
- Self-configuration would be considered as kind of adaptation
- Configuration with respect to the environment conditions and constrains

8. Control:

Control uses algorithms and mathematics to regulate the behaviour of devices or systems.

9. Cooperating Robots & Ambient Intelligence:

Approach to coordinate multi-robot systems which consist of a (large) number of physical robots and possibly external sensors, such that a desired collective behaviour emerges from the robot-robot interaction and the interaction of the robots with the environment.

10. Dependability:

Dependability refers to the level of the ability of a robot to perform a task reliably, safely and with a high level of integrity. The robot itself is dependable if it is maintainable, available, robust, secure, and performs the tasks expected of it. Acceptable and relevant aspects of dependability are very much task/mission dependent. Dependability can be increased, for example, through autonomic capacities such as self maintenance, self-diagnosis and self-repair.

11. ELS (ethical, legal, social):

ELS summarises a class of requirements of the provider, owner and user or of other parties referring to ethical, legal or social aspects touched upon due to the robot system's design and/or operation.

Examples:

- Certification, compliance to regulations, liability
- Considerations regarding the environment of the system, e.g. the workplace
- Labour displacement
- Treating confidential or trustworthy information regarding, for instance, medical information or purchase choices
- Ethical aspects regarding the user, e.g., how the robot interacts with young people, children or vulnerable users
- Ethical aspects regarding the task performed through the system, e.g. in military, civil engineering, medical or healthcare environments
- Ethical aspects regarding which parts of society has access to robots
- Global social aspects regarding the impact of advanced robotics' applications on society (industrial robotics, health care, service, edutainment, educational robotics);
- Identification of techno-ethical concepts and principles
- Application of the Precautionary Principle in all the sensitive cases
- Identification of ethically sensitive aspects
- Obligatory cost benefit analysis
- Position of humans in the control hierarchy
- Extending human possibilities with robots, for example, through bionics
- Bionic experiments on animals
- Warfare applications of robotics, bionics, and others

12. End Effector/ Gripper/ Dexterous Hand:

End effectors enable a robot to interact with and change its environment, e.g., by grasping, manipulating and processing objects.

13. Hazard:

A situation which poses a level of threat to life, health, property or environment. Most hazards are dormant or potential, with only a theoretical risk of harm, however, once a hazard becomes 'active', it can create an emergency situation. There are a number of methods of classifying a hazard, but most systems use some variation on the factors of likelihood of the hazard turning into an incident and the seriousness of the incident if it were to occur.

14. Human-Machine Interface:

IO-System to permit human interaction with the robot system. It enables the human and robots to communicate with each other and allows the human to command the system. Efficient human machine interactions depend on the design of the interface.

15. Human-Robot Interaction:

Human-Robot Interaction is the ability of a robot and human to mutually communicate tasks and outcomes. This may include the collaboration during the execution of a task. This interaction involves the ability to communicate using a common context which may include a common cognitive view. Communication can take place via multiple modes: oral, through gestures, physical interaction or environment changes.

16. Knowledge Systems:

Systems used to gather, amalgamate, filter, store, create, manipulate and categorise information from a variety of sources. They include knowledge bases and their representation: knowledge that allows you to use and work with the systems; source, storage, knowledge memory systems and retrieval paths for the knowledge and information data.

17. Learning:

Changes in the knowledge base of the robot gained through interaction with the environment (including people) that may result in a persistent change to the robots behaviour. In other words, learning refers to the improvement through practice or teaching.

18. Localisation:

Localisation is a methodology used for navigation. It aims at determining the location of a robot or part of it in the environment. Relative localisation is a position measure in relation to local environment – wall, specific object. Absolute localisation is a position measure in a global sense (on a building plan, on a map, with ground coordinate).

19. Locomotion:

Locomotion is the power or ability to move using propulsion and propelling technologies; the act of moving from place to place. Propulsion technologies are key elements for robots acting in the environment. It is the development of devices allowing the movement of the robots in air, on water, under water, inside the human body and on the ground.

20. Manipulation & Grasping:

Manipulation is to treat or operate on an object, especially in a skilful manner. Manipulation can be performed with the hands or by mechanical means. Handling an object delicately; for example; with fingers is referred to as dexterous manipulation and often includes some kind of object perception.

Grasping is a particular form of manipulation. It involves picking up and moving objects with the end effector (e.g., arms, fingers, grippers).

Examples:

- Flexible Manipulation to handle complex objects at high speed. High precision movements may be needed.
- Remote handling

21. Materials:

Robotic parts and systems are composed or can be made of a variety of elements or substances. Materials are chosen to facilitate and implement certain requirements of the system through their characteristics.

22. Mission:

A mission is an overall goal for which no method of how to achieve it has yet been defined. Usually, to achieve the mission, the fulfilment of a set of tasks with which a robot or group of robots is charged, is necessary.

23. Modelling:

Modelling is the process to describe a robot system and / or its working environment including its aim and functions. It is a mathematically described approximation of reality. Models are used by the engineers during the design process, e.g. through simulation of the kinematics, dynamics and mechanical properties and by the embedded software at run-time.

24. Navigation:

Navigation is the process of controlling the movement of a system from one place to another reliably. It relies on mapping, localisation and collision avoidance.

25. Perception:

Perception is the ability of a robot system to become aware of the physical world for modelling and control purposes through the interpretation of sensor data. The robot builds representations of the physical world based upon sensor data and assigns attributes to those representations. This sensor data is interpreted in the light of experience and includes a capacity for connecting sensor data to modelling ability.

26. Physical Properties:

Physical aspects describe explicit customer or environment requirements asking more detailed explicit physical characteristics as constraints of the design of robot systems.

Examples:

- Shape and size, e.g. miniaturisation
- Weight
- Human compatible (e.g. ergonomic)
- Low generated noise and vibration
- Reconfigurable robots or modularity, e.g. by building blocks
- Environmental compatibility, e.g. hygienic, clean-room, explosion proof, shock resistance, chemical resistance (includes water resistance), temperature resistance, vacuum resistance or radiation resistance
- Customisation options

27. Planning:

Planning is the computation and selection of tasks, policies, and procedures for goal-directed robot behaviour. Planning may comprise path planning, motion planning, grasp planning, task planning, mission planning and resource coordination.

28. Positioning / Mobility:

Changing position or moving to a defined place in the robots operating space. Movement refers either to the robot system (mobile robot), an end effector or an object (stationary robot). Parameters are dexterity, precision, speed, repeatability and energy efficiency.

Examples:

- Environment of the movement can be: ground, both internal (room, multi-room, multi-floor) or external ground (flat surface, open terrain, hazardous terrain), bio-environments, water (surface or sub-surface), air or space.
- The accuracy of the movement can be absolute, local, or wide area with respect to the end-point or the path.
- Movement may occur to realise a task under better conditions.

29. Power Management:

Set of technologies generating, storing and conditioning power to the system and to ensure that the system makes the most efficient use of the power available to it at any given time while still performing its task or in degraded conditions.

30. Process:

A continuous operation or treatment conducted to an end especially in manufacture. A process is a sequence of actions or operations (continuous and discrete).

31. Process Quality:

Group of requirements for methods and control of the process performed by the robot. The focus can be performance quality, level of fulfilment, consistency across several workstations and the success level of the robot. The process quality can describe the level of fulfilment of the mission, the level of autonomy and the efficiency of the robot. It also refers to the timely behaviour as a characteristic of quality: On-time, over extended time, lifetime.

Example:

Today the output of robot systems is significantly superior to human performance in very specific tasks and processes and significantly worse in others. In the future, the range of tasks in which robots outperform humans is expected to significantly increase, but for the foreseeable future this will not be true across all tasks and sectors.

32. Programming:

A program is a sequence of coded instructions that can be inserted into a robot. Programming is the process of creating such an instructional program. Ways to program a robot include text and graphic based online and offline programming as well as programming by demonstration or teaching.

33. (Real-time) Communication:

Hardware and software communication within the system's time constraints in the context of its architecture.

34. Robot-Robot Interaction:

Robot-Robot interaction is the cooperation of multiple robots (fixed or variable number) in the achievement of a common goal done through carrying out the task/actions in a coordinated way for example by splitting the task. The robots may access information gathered by teammates or from other sources.

Examples:

- Industrial robots handling large or heavy objects through geometrically coupled operation.
- A manufacturing process can be optimised through the cooperation of two or more robots, where one holds the tool and the other(s) the work piece.
- Several digger robots moving of a pile of sand where they interact through the modification of the environment only (Coordination through the environment).

- Fingers of a hand interacting with each other when fitting a nut onto a bolt or handling soft materials.
- Robots cooperating with each other in order to supervise a wide area.

35. Robustness:

A system ability to meet the specified requirements (e.g. performance) even in adverse situations (hardware failures, system overload). Robustness may be defined and measured at component level and at system level, but typically the two levels are mutually dependent. The robustness not only depends on the robustness of each constituting part (both hard- and software), but also depends on the redundancy and the potential use of this redundancy.

36. Safety:

Aspects of a system designed or measures taken to avoid or handle hazardous situations. The goal is to transform the severity and likelihood of risks that are inherent in all human-machine interactions to lower, acceptable levels. Current norms only cover injuries, but aspects such as robot damage and damage to the environment may also be considered relevant.

37. Sensing:

Sensing is the process of obtaining sensor data.

38. Sensors:

A sensor is a device which detects or measures a physical quantity and converts it into a signal which can be used by the robot system.

39. Standardisation:

Parts of robot systems or component that are accepted, used, or practiced by most people within the business are standardised.

Examples:

- Safety standards
- Software modularity
- Normalisation
- Mechanic, electric, electronic interfaces
- Architectures

40. Sustainability:

Reflection of the environmental impact that the robot's production and its operation have.

Examples:

- Saving energy through intelligent energy supply and management and efficient actuators, processing and sensor devices
- Saving material and minimising waste throughout the lifecycle of the robot
- Considering health aspects
- More economical production of the robot itself, but also through its applications
- Environmentally friendly production by eliminating toxic materials
- Improved sustainability due to the use of robots, e.g., less paint required by robot than by human worker due to higher precision.

41. System Architecture:

Architecture defines the structure of system components, their interrelationships, and the principles governing their design and evolution over time. It is a programmatic description of a system, which outlines how the components of a robot system are organised and integrated. It encompasses both hardware, software, and the processes used to build and integrate them.

42. System Engineering Tools:

Set of tools for engineering a robot system, such as:

- Design
- Software and mechatronic development tools
- Simulation of kinematical and dynamical properties of the robot system (hardware and software) and its environment.
- Deployment of a robot in its environment.

43. Task:

A task is usually an assignment of work often to be finished under certain constraints (e.g. time). A mission can often be broken down into several tasks between which interdependencies can then exist. The analysis of a task often results in a hierarchical representation of what steps it takes to perform the task.