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Handling Robots Equipped with Highly Redundant Sensors

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Abstract: Flexible and adaptive robot manipulators are useful to automate or assist diverse tasks in laboratories. Neuronics AG has developed a light-weight robot manipulator which is equipped with sensors of different modalities. This allows easy programming based on teaching and training sets which categorize sensory data based on examples.

Keywords: Grippers · Katana · Neuronics · Robot manipulator · Sensors

Introduction

20 years ago, robots worked in a well-defined environment based on a Cartesian coordinate system and position encoders in a more or less 'blind' way. Since then, more and more sensors are involved in robot-based solutions, including different kinds of optical, acoustic, force and tactile sensors.

Typically, companies specialized in system integration realize projects by integrating robot, grippers and sensors from separate suppliers, conducting an individual solution for a customer. Thus, the price for such solutions is usually rather high. In addition, the costs to protect human workers from the dangers caused by the robot takes additional space and money. As, on the other hand, the return on investment should be realized in a very short period of time, and flexibility, including full mobility, is more and more necessary, new solutions are focused on reducing the engineering costs.

One alternative is to provide a nearly finished but still highly flexible solution to the customer. Such a 'suitcase solution' (Fig. 1) contains the robot, grippers equiped with a highly redundant sensing system and software which is able to adapt the behavior of the robot to final positioning of the sensors and the meaning of the signals to the particular task.

For applications in environs like chemical and biological laboratories, flexible and light systems that involve a robot assistant performing boring tasks to release well-educated staff for more complex tasks are increasingly in demand.

Fig. 1. Katana represents a suitcase solution including robot, gripper, task related fingers, and software

Robot Arm KATANA

'Katana' fills a gap in the field of laboratory automation. It is a programmable robotic arm with fully integrated electronics (Fig. 2 and 3). It is able to operate with high precision in four to six degrees of freedom. Available as a stand-alone system, on a linear axis or on a mobile platform, Katana is uniquely versatile. The use of Harmonic Drive Assembly as the main gearbox allows very precise 3D positioning with a minimal play per axis (typically 0.01" in space).

Fig. 2. Katana5M: 5 motors/5 axes

Fig. 3. Katana6M: 6 motors/6 axes

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In the field of laboratory environment, Katana can be used for a wide range of applications including picking and placement of plates or tubes (Fig. 4), loading and unloading of centrifuges, incubators, readers, washers, *etc.*

With a weight of only 3–4 kg, Katana has an astonishing payload of 500 g. Its working space extends in an approximate 50 cm radius from its center of rotation. Direct control of Katana is possible *via* a serial interface by a PC, a programmable logic controller (PLC) or mobile robotic interface. Several bus systems and SPS standards are supported. The software (Fig. 5) with incorporated neuronal network tools allows easy programming and fast set-up. The customer is able to define training sets for individual combinations of sensors and actuators.

Fig. 4. Sensor controlled tube-handling presented at the Lab Automation exhibition in Palm Springs, CA, February 2003

Fig. 5. The software Katana 4D allows easy programming *via* laptop or personal computer

The Inventors

Neuronics AG was founded in 2001, based on a four-year development as a spin-off company of the University of Zürich. The team integrates know-how in artificial intelligence algorithms, sensory systems, mechatronics, and distributed control. The products are used worldwide in different industrial submarkets including sensor production, nuclear fusion center, pharmaceutical- and medical lab automation as well as for research and mobile robot applications.

Partners

Neuronics has been able to agree on a partnership with the largest company for industrial robot grippers of Europe (Schunk & Co.GmbH, Lauffen, Germany), who will cover the industrial sector of general automation and system integration. In addition to general automation and mobile robot markets, few industrial sectors are focused for specially adapted turn-key solutions. These submarkets are targeted in collaboration with market leaders in the respective fields. For lab automation, a partnership with IMiX GmbH, Reinach, Switzerland, has been established. The delivery to the end customer is organized through distributors and OEM partners.

Grippers with Sensors

The gripping systems typically include a combination of several sensors which serve to detect and categorize objects as well as obstacles. In collaboration with Schunk, IMiX and OEM partners, optimized grippers have been developed for specific handling tasks in laboratories.

The standard sensors consist of position-encoding units, infrared sensors, force sensors and conductivity measurement. Other sensors like ultrasonic or video cameras can be built into the gripper to allow perfect positioning and shape recognition.

Controlling Software

Katana4D is a multi functional software to pilot and program the Katana robot. Features are:

- Manual command of all motors by mouse click
- Spatial teaching and programming in Cartesian coordinates
- Easy programming of automation tasks by scripts
- Rich Fourth Generation Programming Language
- Integrated Web-Server
- Relational Database, with possible Server-Client-Architecture
- Built in neuronal network allows learning and decision-making processes
- Runs on all Windows platforms (95 and higher) and MacOS

Additional source code in C++ or Java (also for Linux) including demo applications for free, to allow customers to build their own application or integration in existing automation concepts.

Advantages (Table)

The advantages in comparison with traditional industrial robot arms are:

- Weight only about 3 kg
- All electronics included within the arm
- Includes about 20 sensors (encoders, infrared, force, resistance), allowing adaptive behavior
- Flexibility: easy to mount, easy to change programs
- Distributed processors and training based learning of object handling and trajectory optimization
- Human-machine handshake possible without dangers

Table. Physical data for the KATANA robot arm

	KatanaHD5M	KatanaHD6M
Motors	DC motors with integrated digital position encoders	
Precision	<0.1 mm (repetition accuracy)	
Base height	184 cm	188 cm
Degrees of freedom	4 or 5 (5 motors)	5 or 6 (6 motors)
Working radius	55 cm	60 cm
Construction	Anodized aluminium	
Weight	2.8 kg	4.1 kg
Payload	500 g	500 g
Power	3 A at 12 V	3.5 A at 12 V
Velocity	90° in 1 sec (all joints move in parallel)	

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