Pneumatically Driven Robots

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ABSTRACT

Typical industrial robots show a characteristic of an inelastic structure and stiff servo drives. Exactly these features give traditional robots a very high positioning/repetition accuracy, which is a must in many industrial applications. In case of physical contact high forces occur due to their inelastic characteristics. Sensors and control tools could compensate the problematic effects of these forces. But now the new concept of pneumatically driven robots solves this special requirement without any additional sensors.

1. INTRODUCTION

FerRobotics Compliant Robot Technology GmbH located in Linz has developed a new generation of flexible light weight robots based on physical compliance. This new technology is vital to provide a vast variety of new industrial tasks as well as in medical technology. Its compliant structure now allows to perform industrial purposes gently even shoulder to shoulder. The integrated show-do programming offers the possibility to set up any new work situation easily. For both medical technology and healthcare a physically compliant device provides help in many aspects. To support nursing or as a sort of every day life aid however assisting robots turn out to gain increasing importance in our society.

In important industrial applications like grinding and polishing or insert material in production units the actual contact with the job environment is an essential qualification. Therefore the idea of an elastic robot was born at the Johannes Kepler University of Linz. This new robot generation with elastic drives found high interest in the production industry and finally lead to foundation of the spin off company FerRobotics Compliant Robot Technology GmbH.

The innovation of these new "sensitive robots", see Fig. 1, now show an outstanding characteristic due to the compliance and flexibility of its components combined with an easy "show-do" programming- the latest robot technology in a straight forward setup.

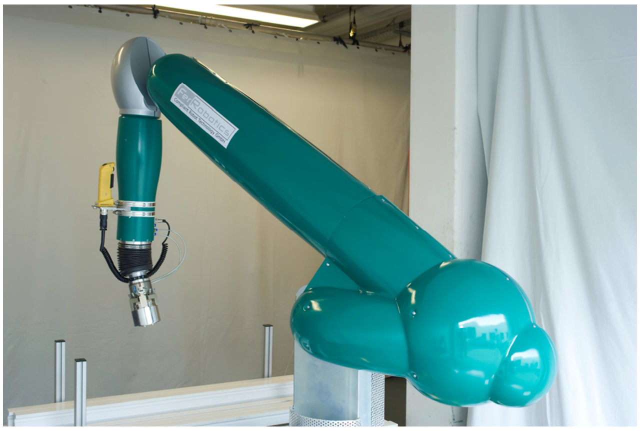

Figure 1: 7-axes robot ROMO of FerRobotics

2. ELASTIC ROBOTS

The application of elastic robots is becoming more and more important. Elastic robots can be classified into three different elastic variants. Figure 2 shows different options of elastic robots.

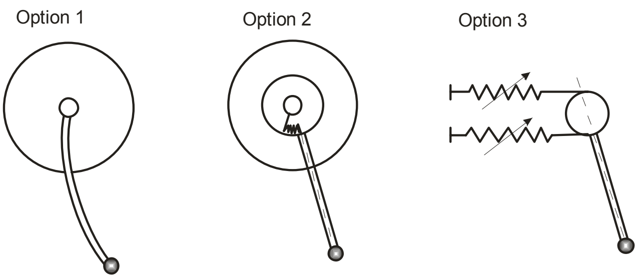

Figure 2: Variants of elastic robots

The first option uses a motor and a stiff gearbox. The drive side is an elastic bar. The effort of modelling and control is in this option enormous. Additionally, to compensate elastic oscillations the bending in different positions has to be measured, see also [1], [3], [5].
Option 2 consists of a stiff drive with gear elasticity, see also [4]. An example of this type is the LWR III of DLR , see [6]. This robot has two angle sensors, before and after the gearbox and a torque sensor in every joint. With these components control algorithms can produce elastic behavior.
Option 3 is the principle of ROMO. Linear pneumatic actors provide the elasticity in the drive. The pressure and the joint angel need to be measured.

3. BIONIC APPROACH

The robot with the linear pneumatic actuators, so called "air muscles" is inspired by nature. The technical transfer of ideas from nature is called bionics. In our device the bionic approach reflects in different system levels or domains. The highest system level is defined on the system behavior. The FerRobotics robot is characterized by its physical compliance and its sensitivity. Its setup is the technical conversion of a human arm. This structure induces advantages of the system and application advantages:

- quick and easy handling
  …(palletizing, pick&place)
- soft positioning
  …(to apply rubber foam/fleece; assistance devices)
- 3D-contour tracking with defined contact pressure
  …(deburring, grinding, polishing)
- lightweight construction allows mobile use
  …(applicable on mobile platform)
- flexibility guaranties robust characteristic
  …(robot avoids collision)

The different domains also implement bionic patterns. A robot is a mechatronic product in which the mechanical level, the electrical level and the software level are linked, see [2]. The idea of ROMOs mechanical design comes from the locomotor system of a human arm. ROMOs joints are connected with a lightweight framework and driven by elastic muscles. The motion is controlled by two different mechanisms, the brain (high level central system) und the nervous system (low level central system), see Fig. 3.

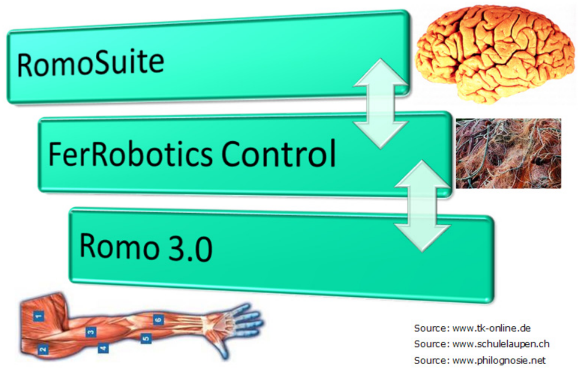

Figure 3: Structure of ROMO

The structure is characterised by the interaction and co-operation of :

- Romosuite – The Brain
- FerRobotics Control – The Nervous System
- ROMO 3.0 – The Locomotor System

3.1. Romosuite – The Brain

The software and the user interface, the so called romosuite is comparable to the function of the human brain, which controls the actuators and processes the sensor signals of the locomotor system.
The suite is responsible for certain tasks e.g. path planning and program processing. Jobs are built up by „intelligent" path segments, which use an environmental feedback.
The programming precedes by defining of support points with tolerances, actions and conditions. These support points are connected by paths with tolerances and conditions. The cyclic execution, where path segments are chosen dynamically by sensor values and a trajectory, is generated in real time. The „intelligent" support points perform also gripping and tool actions. These paths and points are visualized 3D in combination with an online model of ROMO, see figure 4.

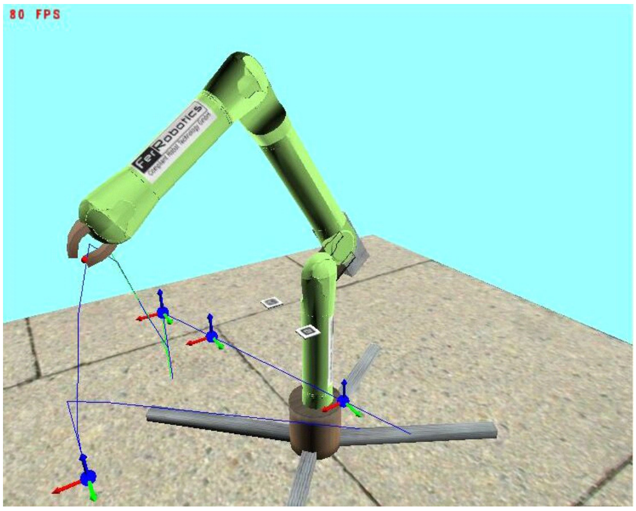

Figure 4: Online Visualisation in Romosuite

This approach to program via a state diagram offers a natural approach to the subject, see figure 5.

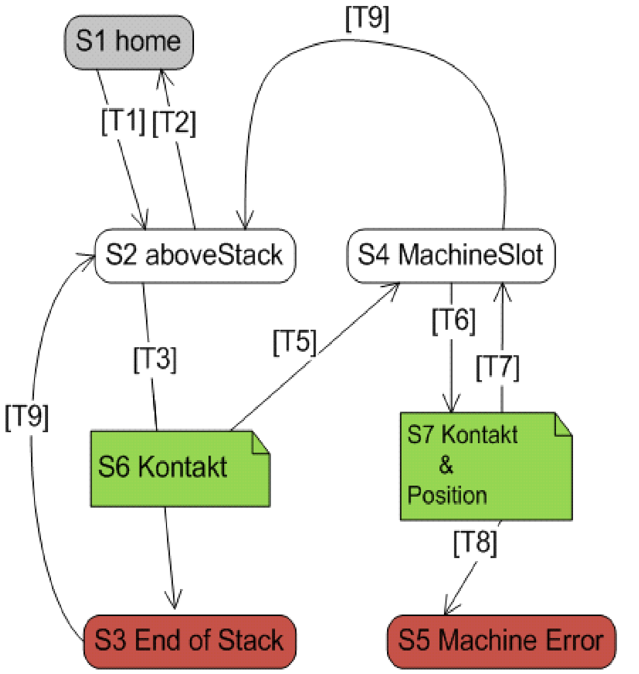

Figure 5: State Diagram of a stacking job

Figure 6 shows the interactive behavior vs. traditional programming.

Stack (S1) positioned exactly	**Find stack (S1) by touch force**
for i=1 to #pieces move (S1) move (S1 - i * p_size)	Repeat cycle (#pieces) move to S1 *touch upper position*
gripper command	gripper command
move (S1)	
move (S2), ...	move *from act. pos to* S2
end	end
exception handler: firstly STOP, afterward RESET robot	exception handler: STOP/SLOW, then *continue* to next SP after error is cleared

Figure 6: State Diagram of a stacking job

3.2. FerRobotics Control – The Nervous System

The FerRobotics control is a humanlike sort of nervous system. ROMO has implementet a sort of reflex, which is generated by the control system and and is not released by the suite. There are also diagnostic functions integrated on this level. The general controller structure provides a functional base for the generation of the source code. In a next step the source code is integrated in an automation link. Finally the implementation on a real time system completes the actual process, see fig. 7.

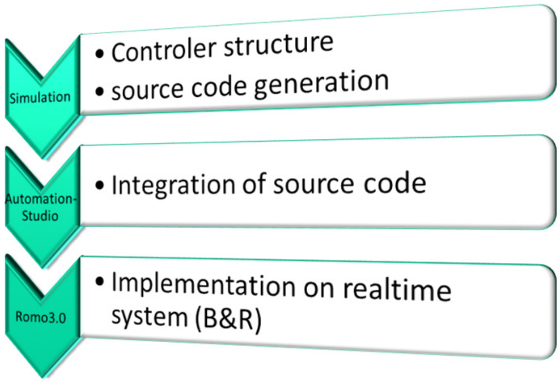

Figure 7: Generation of FerRobotics Control

3.3. ROMO 3.0 – The Locomotor System

The ROMO drive concept uses air muscels (made by Festo) and electric motors (power cubes from Schunk). To ignite a driving torque on the driven arm the pneumatic configuration copies the muscle concept of a human arm. Two air muscles (agonist – antagonist) need to be controlled (fig. 8) so that they can execute their translational driving power.

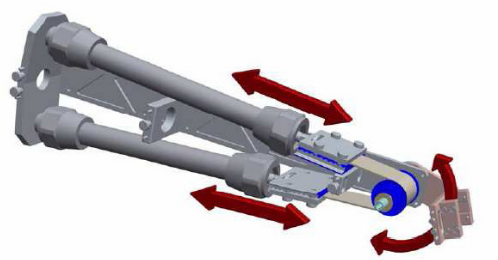

Figure 8:Drive concept

4. APPLICATION PROSPECTIVES

This new robot generation with its outstanding characteristic allows totally new application concepts. Its physically compliant nature allows access to contact sensitive applications as a standard solution. This special characteristic is a big benefit for the industrial use, besides allows new concepts for medical equipment and even gives amazing options for fitness purposes and virtual reality. The simple show-do programming now makes the robot a multitasking tool for individual jobs.

Thanks to this innovation small and middle sized producers or those who are dealing with varying production processes now also have the chance to take advantage of the automation benefits. Considering the fact that exactly this company type represent the majority of the domestic producers underlines the economical impact of the FerRobotics robot technology.

Medical engineering demands intelligent and cost efficient solutions. A soft robot technology offers fantastic applications in many aspects. The demographic development of our society requests human orientated support of the nursing experts. Further more the actual trend in hospital aftercare shows a shift torwards guided home training. For all these application aspects save and flexible devices with easy individual handling and optimal data analysis are required.

In terms of fitness applications all types from preventive goals, remedial exercises, traditional fitness workouts up to special force trainings for professionals are potential beneficiaries of the new soft robot technology. Following the trend and the economical limits modern high-tech solutions provide optimal solutions for all types. Already now it is obvious that soft robots are going to enter not only fitness studios and therapy centers but private homes as well.

Virtual reality and simulation is one of the youngest and therefore trendiest robotic sector of all. The implementation of the latest robot inventions allows to satisfy the forcing demands of a continuously forward heading society sector.

It is the actual availability of a technology solution like the FerRobotics compliant robot technology that allows the induction of new application genres in the interplay with the creative use of it. This means, right now we only just have entered the path of integrating soft and flexible robots in the wide spectrum of options.

5. REFERENCES

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