STANDARDISED INTERFACE AND CONSTRUCTION KIT FOR MICRO-ASSEMBLY

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Abstract Automated assembly of microsystems is often characterised by small batch sizes combined with high product diversity. This characteristics demand a large number of endeffectors. In the last years in particular grippers have been developed for automatic assembly of hybrid microsystems. These have been optimised for a specific task and have one thing in common: there is no compatible interface. From the economic point of view the application of a construction kit is a sensible approach enabling both:

- **quick system configuration** as well as initial operation of customised automated solutions and
- **quick system reconfiguration** for adapting the customised handling system to different applications even in the process. In this context standardisation of interfaces is obligatory for universal application and expandability of the system.

However, up to now the field of microsystems assembly is also characterised by strict specialisation of automation solutions to specific tasks and consequently low modularity and rare standardisation of interfaces.

1 Introduction

In general construction kits for robotics have existed for 15 years. They consist of:

- a set of endeffectors,
- an optional tool change system (see Figure 1 left) enabling fast reconfiguration for different applications,
- a positioning system (e.g. swivel units as one representative component, see Figure 1 middle and right).

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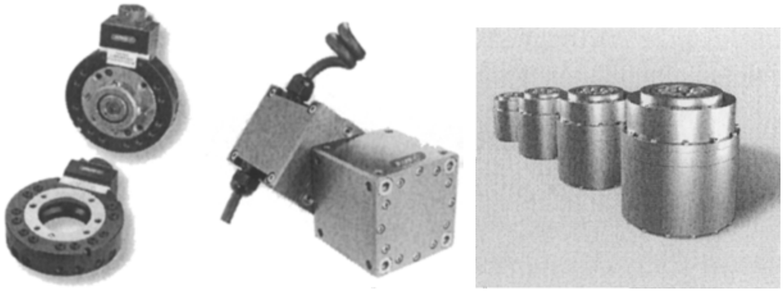

Fig. 1. Left: Gripper Change System (diameter >50mm)
Middle: PowerCubes® since 1991
Right: Swivel Units

To obtain an adequate construction kit for the world of fine mechanics or micro technology requires downscaling the existing modular solutions mentioned above. However, the downscaling process is coupled with the request for increasing precision and energy density. Thus modular solutions in robotics have rarely as yet been transferred into the field of precision engineering or microtechnology.

This paper presents a construction kit for micro robotic applications containing the following modules:

- **Endeffectors** (example see Figure 2 left)
  The endeffectors currently consist of different grippers and will be extended by alignment modules, fine positioning units, compliance modules, etc.
- **Micro tool change system** (see Figure 2 right)
  Beyond the mechanical coupling of the grasping module to the handling system, the micro tool change system comprises also electrical and fluidic lead throughs as well as a central aperture.
- **Positioning system** (see Figure 3)
  The positioning system consists of miniature swivel units, rotation units and base profiles variable in length. They are characterised by watertightness, extremely compact build up and integrated electrical and fluidic lead through.
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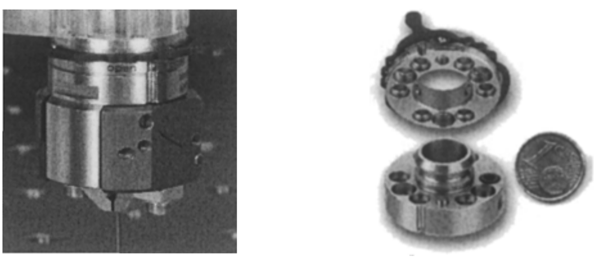

Fig. 2. Left: Endeffector: Parallel Micro Gripper (with integrated standardised interface) Right: Micro Tool Change System

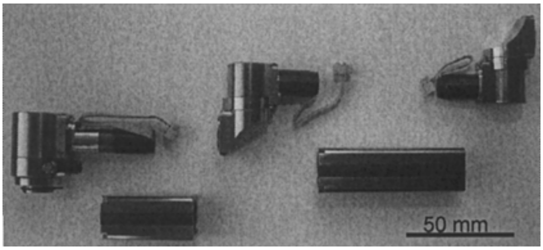

Fig. 3. Positioning System Components

The micro tool change system and the endeffectors conform to the new standard "DIN 32565: Interface between Endeffector and Handling Device". The standardisation of the interface plays a central role in mounting customised handling systems. It assures straightforward exchange of different modules. This is a precondition to perform complex assembly tasks at small batch sizes economically. The standard can be introduced to the international audience of the IPAS seminar as a domain base for micro assembly.

2 Research methodology

Cartesian systems have a good ratio of workspace to overall size and can be realised for high load, high precision and high stiffness but are consequently heavy and cost intensive (like granitic-bed in temperate surrounding). Innovative delta kinematics are absolutely precise and enable short cycle times. However, as they are usually installed overhead, these kinematics require high installation effort and adequate installation space. Additionally both systems require protection devices.

For micro- and nanopositioning in the laboratory environment, e.g. piezo electrical actuator based positioning systems, operating a range of operation of some millimetres, have been increasingly applied in recent years. Currently, systems containing such high precision actors are extending from scientific to industrial use. However, requiring powerful control units, they are cost-intensive and therefore are only used for assorted applications.

An economic use of fixed handling systems requires adequate quantities and capacity utilisation. In the case of moderate lot sizes, automated handling can only be carried out with accordingly lower investment costs. Additionally, in order to maximise capacity utilisation the system should be easily portable and configurable to different kinematic and geometric variations.

Recapitulatory, a system with the following properties will be introduced:

- Reduced costs of investment and installation to enable economic operation even **with low capacity utilisation** on the one hand and
- configuration variability and portability to **maximise capacity utilisation** on the other hand.

An actual industrial initiative is in progress for miniature robotic handling with the goal of optimised required space, portability and high configuration variability. As a consequence new solutions have to be found to receive the required preciseness. A level of precision suitable to the application can be reached economically using an optical feedback in combination with closed loop controlled fine positioning axes at the front-end. A key characteristic here is a central aperture through all modules of relevance like the gripper, its interface and the rotary unit in order to realise direct process monitoring.

The handling system exemplarily introduced in this paper is based on the "Scara" kinematics (see Figure 4) which is typically known as a compact unit for pick and place applications, where the linear z-axis is located at the robots front end. This configuration is motivated by the minimisation of moments at the linear bearing. However, for realising the central aperture at the robots front end here it was reasonable to locate the linear axis at the base of the kinematics (first axis).

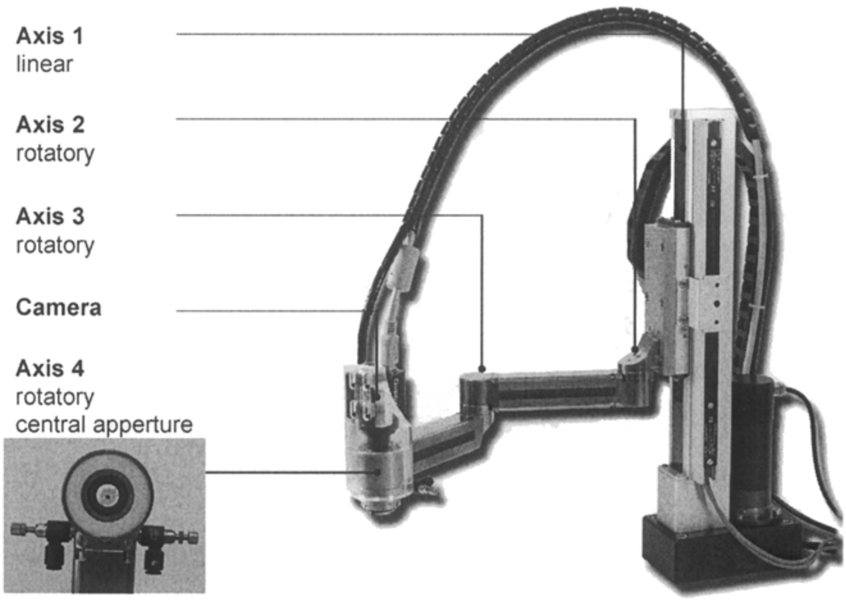

Fig. 4. Miniature Handling System based on Scara kinematics

Making use of the standardised interface DIN 32565, such components guaranty a quick exchange of manufacturer spanning compatibility. Therefore in a first step the micro tool change system mentioned above has been developed. Users and manufacturers of assembly devices as well as research institutes have been cooperating since 2000 for the initiation of the standard and the extension of the construction kit.

Beside the economic requirements, the development of the micro tool change systems includes the following technical requirements:

- Preciseness: In this context the repeat accuracy when changing the endeffectors is of special interest.
- Stability: High load capacity combined with high acceleration requires low deformation at high radial moments.
- Usability: Besides the installation of the interfaces a simple and reliable manual connecting as well as automated connecting and disconnecting has to be ensured.

The main challenges of the development have their seeds in the effects of the downscaling process: while stability can be changing exponentially, the elastic strength is changing linearly by variation of dimension. In consequence new tolerances had to be defined and mechanical principles had to be modified accordingly.

Several research projects like Briolas or Profam (publicly funded by German Federal Ministry of Education and Research), Eupass (publicly funded by European Union) and companies in the sector of system integration like Rohwedder® or MiLaSys technologies® make use of the standardised interface as a design base (see figure 5). So the essential further development is embedded and pushed ahead by the practical demands. Components suitable to the interface, like fine positioning units, optical devices, or whole assembly units have been designed by different applicators.

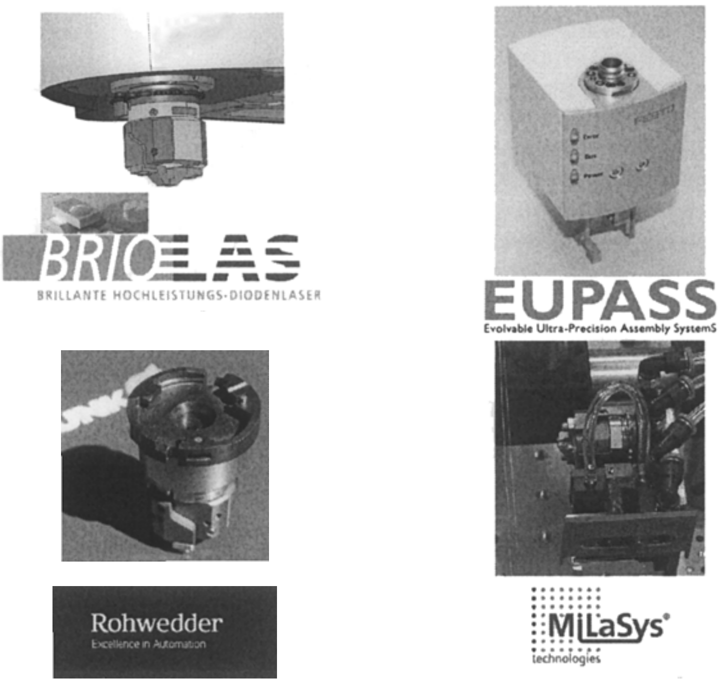

Fig. 5. Examples of first applications of the standardised micro tool change system

3 Major results

One overriding purpose of the paper is to demonstrate the advantages of standardisation in micro technology at large. A basic construction kit for the field of microsystems assembly has been developed with partners from industry and research in the course of several projects. In lieu of solutions specified to the application the construction kit gives rise to economical and modular assembly of microsystems. The standardised interface here is an important step towards cross manufacturer compatibility. The interface between endeffector and machine however is only part of an overall master plan.

Currently the new standard DIN 32565 is applied. It specifies requirements on an interface between endeffector and handling system or between modules. On the front end side of the mentioned micro tool change system several tools can be mounted. An automatic interchange of these tools can be realised provided by a micro change magazine. As a superior system swivel and rotary units have been designed. In a sequence a system will be completed for build up of customised "on table handling" solutions.

The standard has been worked out by the committee "Manufacturing Equipment for Microsystems" in the DIN NAFuO (Optics and Precision Mechanics Standards Committee), the standardisation body for precision engineering and optics. Currently DIN 32565 is transferred to ISO. The committee TC39/WG16 plans to replace the German standard to a world-wide standard in October 2007.

Apart from the mechanical interface the new standard defines also position and specification of lead through for fluidic and electric coupling units. A distinctive feature is the central aperture for optical applications (e.g. laser, camera, etc) or for feeding of parts or media. Only the adapter plate is specified in the standard. This way the realisation of the head plate is up to the equipment manufacturer. The goal of this standard is exchangeability of arbitrary manufacturers. Standardisation is a precondition for a wide dissemination of this interface.

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