THEORY OF COMPUTER AIDED ROBOT CONTROL (CARC)

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Introduction

The computer aided design, analysis, control and simulation of robotized workcells are very interesting in this time. Necessity of computer adhesion for design, animation, analysis and programming of robots and automated workcell is not misgiving. Together exists general spectrum CAD product only for design, 3D animation and commercial presentation, for example: CATIA, I-DEAS, UNIGRAPHICS, Pro/ENGINEER, EUCLID, etc. On the other side we can find special software, which we can use for this purpose, too. There are unique PC based analytical and simulation programming systems, for example: IGRIP (Deneb Robotics), ROBSCAD (ISRA), ROBOT-SIM (General Electric), ROBCAD (Technomatix), ROBEX (RWTH Aachen), KUSIM (Kuka Robotics), etc.

Theory of Computer Aided Robot Control (CARC)

Computer Aided Robot Control (CARC) started as an off-line-programming tool for robotized manufacturing workcells. Its prime purpose was to program robots off the shop floor, thereby providing the operators with a safe working environment, an efficient tool to perform trial-and-error routines, a reduction in maintenance and troubleshooting efforts, and better use of the production equipment for real manufacturing purposes rather than preparation work.

Soon the benefits of using CARC tools upstream became clear. Why use Computer Aided only for programming equipment why not use it up-front, for designing the whole workcell? Enhanced Computer Aided Robot Control - CARC tools enabled manufacturing engineers to design the complete workcell in a faster, optimized and error-free fashion. The ability to view the equipment working in a manufacturing environment allowed for much tighter designs with less error margins, as well as more accurate time and flow calculations.

Thus, CARC tool a significant step forward. Although savings resulting from off-line programming were significant, they were only in the initial phase of production. Computerized process design provided benefits not only in the launch phase, but throughout the product life cycle, as optimized cell layouts and tools paths resulted in reduced capital investment and lower variable manufacturing costs.

CARC systems are analytical, planning, programming and simulation systems, which have next characteristics:

- are a PC or WS based software, dedicated to the analysis of robotized workcells and automated manufacturing systems with industrial robots,
- offers three-dimensional simulation, kinematic and dynamic analysis of manufacturing systems with industrial robots and engineering support of new robotic devices design,
- the controller of any mechanical system the user has graphically created - peermits to rapidly evaluate several different layout solution, reducing errors and allowing a wider range of possible choices,
- can help engineers dimension motors and gear reducers, optimize the dynamic behavior of a mechanical system [1].

Example of possible modules of CARC system is shown on Fig. 1.

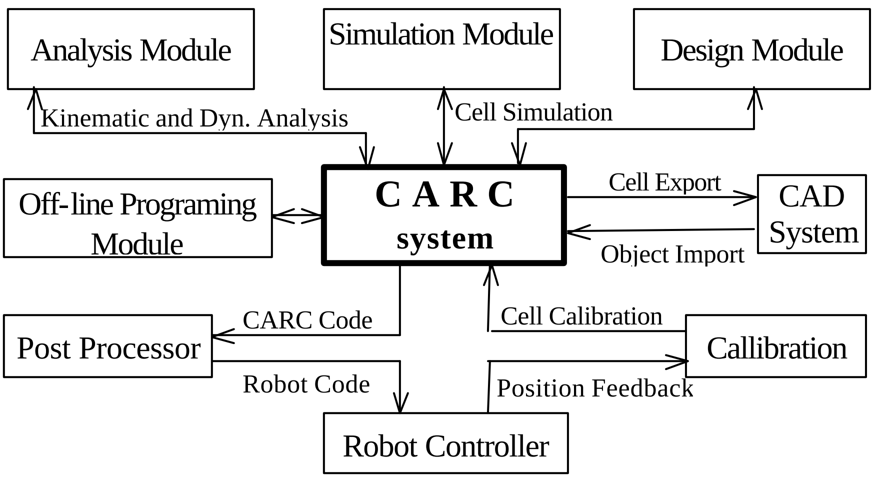


Fig. 1 Scheme of CARC system modules

CARC system is possible to use in several conceptually different areas:

1) *Design and planning of the robotized workcells.*
   The user can create any objects in a 3D editor or import their from CAD systems, then compose the cell by listing and verify the object in it.
2) *Simulating and programming the processes.*
   CARC system has a high level language, working in an interactive way with the graphic representation of the cell. Kinematic routines calculates the cycle time and verify for interferences and collisions. The user can verify be correctness of his multi-tasking programming logic by simulating inputs and PLC communications.
3) *Analysis the data.*
   The kinematic module of CARC system present all information concerning position, velocity and acceleration. The dynamic and drive analysis modules calculate information about inertias, moments, internal forces, dutycycle, and other motor parameters.
4) *Communicating with the robotized workcells.*
   Several post-processor modules are available with the goal of translating CARC system language into the robot code and to translate the robot language into CARC code[4].

ROANS - example of CARC system

The one from interesting of CARC system developed in Presov (Slovak Republic) is PC based software named ROANS. The basic data in ROANS are represented by two structural types, the workcell and object type. The workcell consists of object, where as the object is an elementary entity, further not structured. These data structures are created and updated within the ROANS OBJECT and ROANS CELLS.

1. ROANS OBJECTS

There are five object types in ROANS, every characterized by a specific data:

a) Static object
b) Plates
c) Dynamic object
d) Tool
e) Mechanical system

The 3D graphic editor of ROANS provides the user with elementary editing tools for creating the 3D models. However, user may use also his favorite CAD system to can be the 3D models imported into ROANS (DXF and IGES protocols). The 3D models of object are represented by their surfaces, composed of the planar faces. The 3D graphic model of the mechanical system is based on the 3D graphic representation of its links at one of the three drawing commands: Draw Wire, Draw Solid, Draw Shade.

2. *ROANS CELLS*

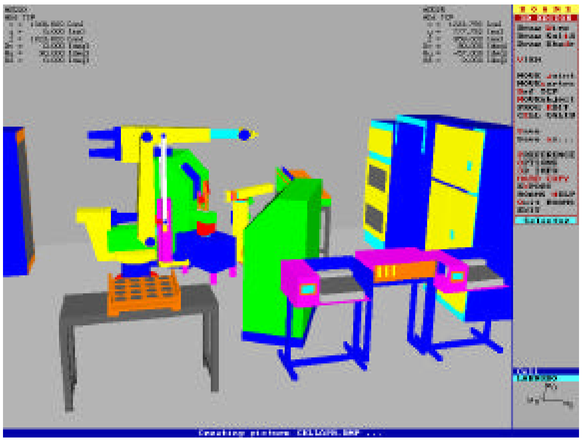
This option still allows the user to create automated workcell, animate it in the 3D graphics and analyze space and work problems.

Workcell is the entity of highest structural level and consists of object, their position is either fixed or changing during the process simulation. After the loading of existing workcell, or after the specification of the name of a new workcell, the workcell data and the workcell layout can be (re)defined. After gets the program control to a multilevel self documenting menu system that provides the user folloving options:

- view of the workcell in various graphic modes,
- moving and manual control of the workcell objects,
- checking the object collision and accessibility of the object,
- graphic interactive editing of ROANS programs,
- position calibration of the workcell object - DXF and IGES export.

Example of the automated workcell with one industrial robot, one welding preparation and with others devices represented on the computer screen in ROANS environment is on Fig. 2.

The working in automated workcell is controled on the base program, designed by operator. The program is prepared in ROANS language. This program is possible to arrange by postprocessor and use for concrete robot control system. Example of program created in ROANS is on Fig. 3.



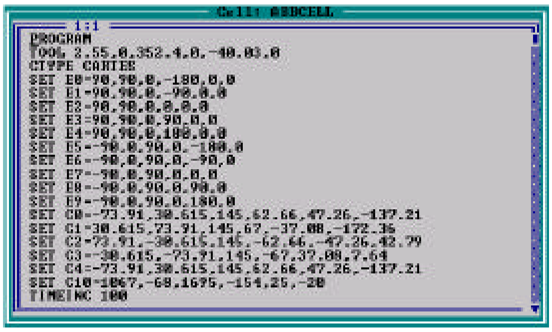


Fig. 2 View on the screen of the ROANS with

Fig. 3 Program in ROANS
displayed model robotized workcell

CARC as subsystem of system CIM

Computer Integrated Manufacturing (CIM) represent the integration of traditional production and engineering technologies with the computer technology, which enable the automation all activities from product design to their expedition (design of products, creation of technological procedures, production planning, operative control, manufacturing of products, quality control, assembly, packaging, expedition, etc.), with goal to bring down of the material and energy pretension, to increase of work productivity, to bring down of supplies, to shorten of development and production time, to increase of time and power utilize of production devices and ti increase of products quality [2].

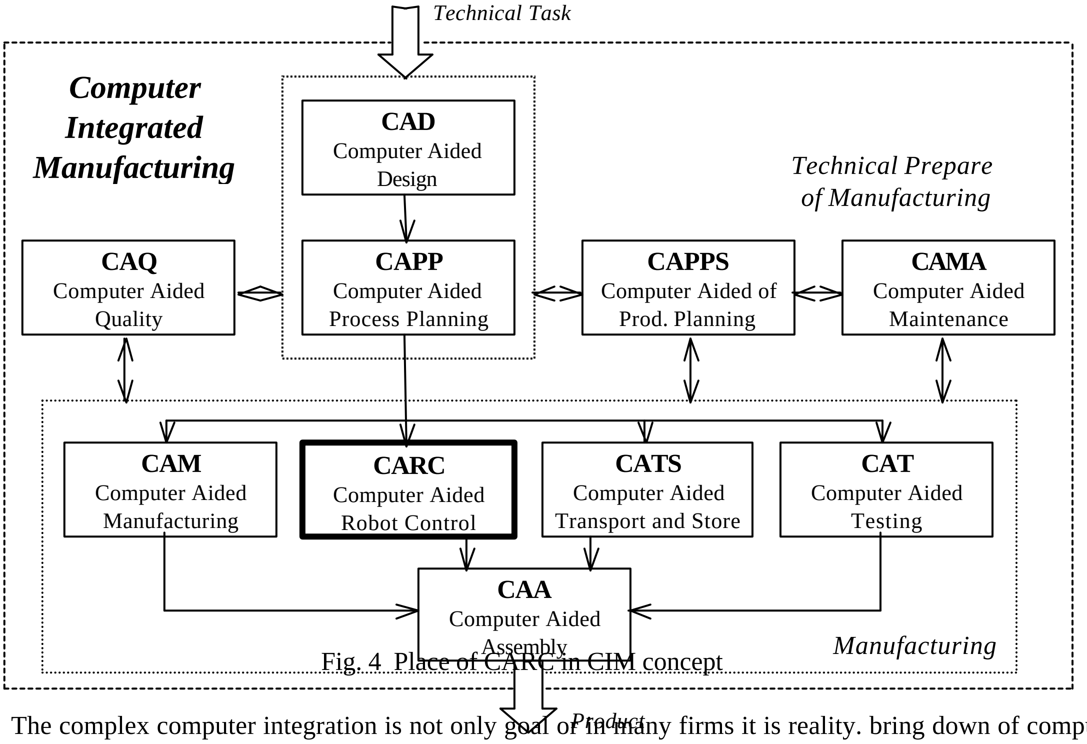


Fig. 4 Place of CARC in CIM concept

The complex computer integration is not only goal of in many firms it is reality. bring down of computer components prices and increase of computer power in unite with modern software technologies, new methods of firm organisation, new progresive technologies condition orientation on modern information and communication technologies in many firms. The CIM systems in most cases is not represented by complex wholes, or they are compile by integration of partial automatized systems - CA systems (Computer Aided Systems).

Computer Aided Robot Control (CARC) is a subsystem of the system CIM including the computer aided systems of all activities connected with realization and working of robotized and automatized workcells (planning of robotized workcells, off-line programming of robots and other devices, simulation of activity in robotized workcells). This stage of computer aided systems in complex CIM fluently establish on applicaton of computer aided systems in technical (construction and technological) preparing of production and is inevitable for secure of concurrent engineering conditions. Place of CARC in CIM concept is presented on Fig. 4.

The enabling technologies for CARC emerged only in the mid-'80s. Simulation, advanced graphics, motion emulation and powerful computers to support them all matured to the extent that CARC technology could be brought into economically justifiable use [3].

Conclusion

CARC system applications cover the 3D graphic animation, programming and design of robots, planning and controlling of workcells, commercial presentation and education areas. Complex task of the 3D graphic simulation and programing of robots and workcells can be carried out by CARC systems on PCs with the performance equivalent to the workstation based systems.

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