EXPERT SYSTEM FOR SPECIAL CONSTRUCTION ROBOTS DEVELOPMENT

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Abstract: The article deal with systematic and system support of the special robots develoment at TU Brno. This approach is based on the robot expert system development. This expert system is developed based on the tradition of robot development at TU Brno, the analysis of robot technologies (for the machine industry, construction industry etc.), analysis of the world industrial robots and robots components, specification of rules and regularities of robots development etc.

Key words: robot, technology, construction, database, expert system, development.

1. INTRODUCTION

The construction robots development at TU Brno, Institute o Production machines, Systems and Robotics is based on the robots development tradition at our institute, on the analysis of the robots development and robot application in the world. We are developing the special industrial robots series for our industry. For quicker and economical special industrial robots development was necessary to solve the computer aided unification, integration, systematic approaches etc. based on the robot and robot components databases and the robot expert system development.

2. CHOICE REGULARITIES OF EXPERT SYSTEMS

Expert systems are usually design based on the computer aided of the difficult tasks solution, that would have solved otherwise by expert for the satisfactory and successful solution reaching. For the industrial robot development and their application are necessary to use several experts: for the robot technology, robot design, robot joints design, el. servodrives, robot control etc. Expert system supports of these team-work, accelerates the solution, enables the computer aided decision and integration of these works on the model.

Characteristic features of expert systems:
-knowledge separation from the mechanism of its using,
-database of the structured information,
-explanation mode,
-modularity and transparency of the knowledge base,
- dialogue mode,
- evaluation of undefinite information,
- rules for the targets reaching etc.

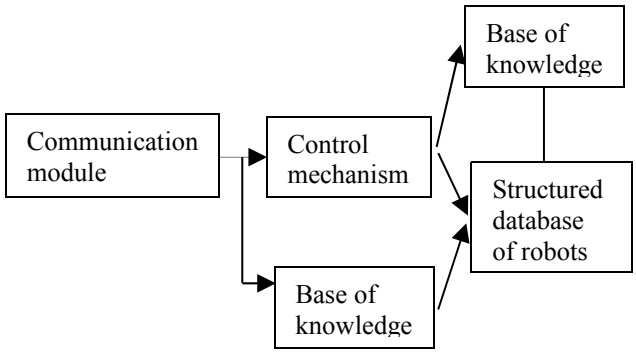

Figure 1. Expert system pro the robot development

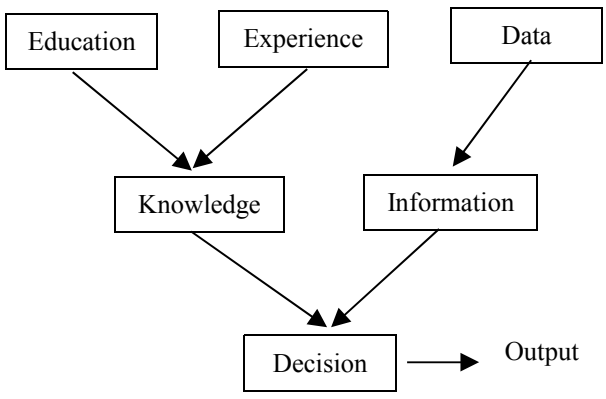

Figure 2. Data and knowledge in expert system

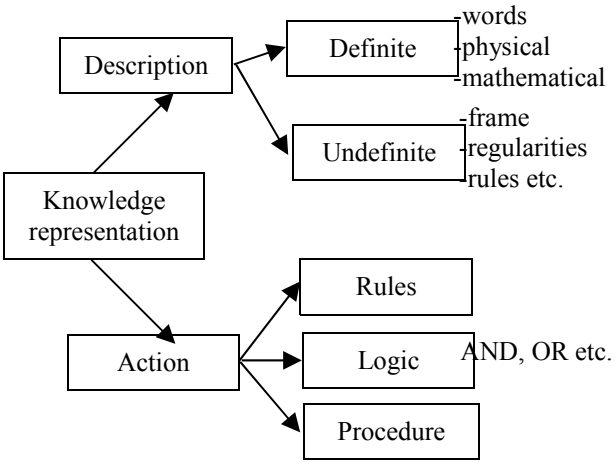

Figure 3. Knowledge representation in expert system

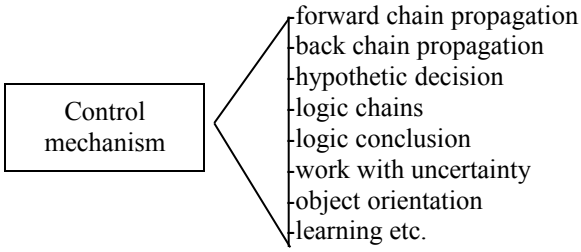

Figure 4. The way of expert system control mechanism work

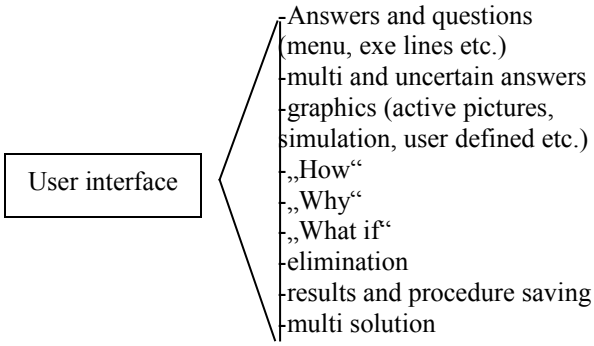

Figure 5. Expert system user interface [4], [12]

3. DEVELOPMENT OF ROBOT EXPERT SYSTEM AT TU BRNO

Based on our industry requirements for the special industrial robots development for various industry application we have to develop the special industrial robots on the scientific conception based on the robot expert system.

The development of robot expert system at TU Brno is based on:
- Tradition of special robots development (design, control and application) at TU Brno
- Analysis of the world industrial robots and their application
- Analysis of the components for the robots development and design
- Databases development
- Development of the robot mathematical models
- Specification of rules and regularities for the robot design and development
- Development of the robot expert system

3.1 Tradition of special robots development at TU Brno

At TU Brno the development of special industrial robots has tradition approximately 20 years. We are working on the series of industrial robots PRKM, PRM and ALR. These series of robots are developed based on the geometric a arithmetic series, technical hereditary etc.

It was developed:
a) The series of the Cartesian portal type robots PRKM
- light weight series of robots, nominal loading capacity 20 kg, 6 dimension members in the geometric series with q = 1.26. The base member of this series is robot PRKM-20 with the working envelope of 3 510 x 865 x 880 mm. These robots are equiped with the stepping motors and synchronous servomotors and computer control system and were developed especially for the manipulation and transport.

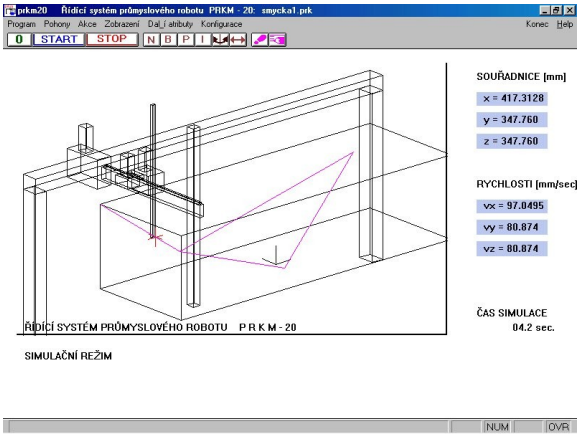

Figure 6. PC control of robot PRKM-20

b) The series of the Cartesian bridge type robots PRM
- heavy weight series of robots, 4 dimension members in the geometric series with q = 1.7, 4 nominal load weights from 55 kg to 2 000 kg after geometric series with q = 3,6. These robots were

tested with DC servomotors MEZOMATIC and PLC control system and were applicated in the construction materials industry for the manipulation.

c) The anthropomorphic robots ALR-4
We are working now on the series of anthropomorphic 6-axes robots ALR-4. Light weight series of these robots have 4 dimensions in the geometric series with q = 1.4, 4 nominal load weights from 2.5 to 20 kg after geometric series with q = 2. These series of robots are prepared especially for the material handling, assembly etc. The maximum of the high reach of the robot ALR-4.1 is 2.2 m. In the future will be prepared the anthropomorphic heavy load weight robots AHR series and light load weight anthropomorphic angular bio robots - ABR series. For these ABR robots we are now developing some of joints with the possibility of bio-application. [1], [5], [8]

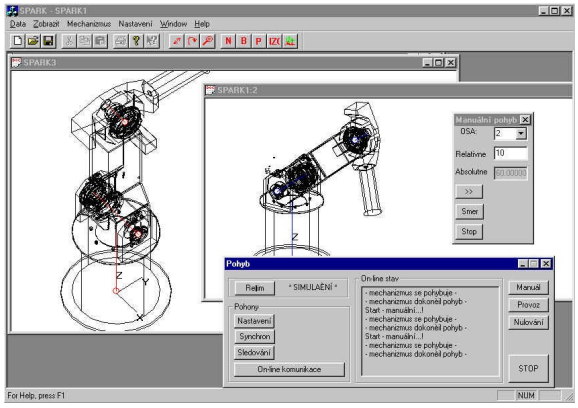

Figure 7. Robot ALR-4.1 module design and development

3.2 Analysis of world industrial robots and their application

The world producers of industrial robots produce only specific range of robots with the working space, velocity, accuracy, DOFs etc. These robots are applicated especially in the machine industry, electrotechnical and electronic industry etc., but is possible to use them in the construction industry for example for the welding, manipulation etc. at OFF-site technologies and for the special operations at ON-site technologies.
The robots development and application is possible to follow in the first step based on the technology, for example the manipulation with materials, assembly, welding etc. These technologies are possible to use especially for the OFF-site technologies for the construction preparation and the prefabricated production, for example the production of windows and doors (frames welding etc.), the manipulation with prefabricated units (for example the using of our robot PRM-55 at the application in the coating material production in the Ceramics factory - Karlsbad, Czech Republic etc.).
For the robot application at ON-site technologies is necessary to analyse these technologies, to develop new robot technologies, new special construction robots and if it is possible to use the produced robots in the world.

Example of world robots arc welding analysis:
- the number of robot analyse: 28,
- the loading capacity: 5 to 50 kg,
- the position accuracy: + - 0.05 to + - 0.3 mm,
- the work space project (radius x height): 1.5 to 6.4 m^2,
- the maximum of velocity in axes: 150 to 240 °/s,
- the number of controlled axes: 6 (at 100% of robots analyse). [6]

These robots are possible to use for example at OFF-site technologies for production of prefabricated units etc. and also to serve us for the comparison of the world robots and our robots development.

3.3 Analysis of components for robots development and design

Some examples of our approaches:
1) Gearboxes (harmonic drives, belt drives, epicyclic gears etc.)
Criterions of choosing:
a) Moment
b) Dimensions
c) Mass
d) Moment of inertia
e) Movement accuracy etc.
2) Electrical servodrives
Criterions of choosing:
a) Moment
b) Dimensions
c) Principles (AC, DC etc.)
d) Mass
e) Convertor etc. [7]

3.4 The databases of the robots and their components development (in Microsoft Acces 97)

The databases enable:
a) Inserting and revoking of the records
b) Questions on the robots, components etc.
c) Creation of the catalogue leafs of robots and components.
The databases have in this time approximately 100 catalogue leafs of robots and we are working on the components catalogue leafs.

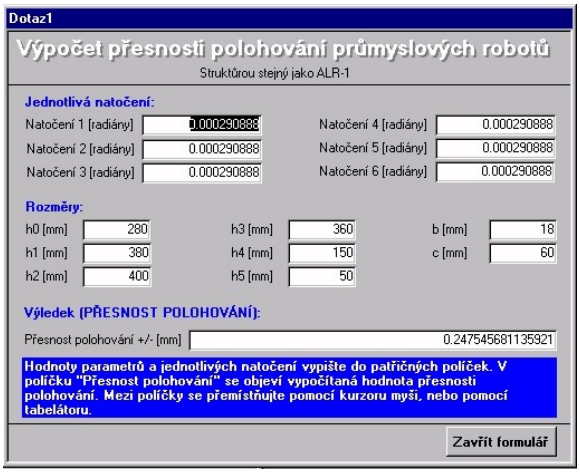

Figure 8. The development of the Robot Database

Figure 8. shows the calculation of the robot position accuracy based on the robot kinematics and the robot joints accuracy.

Figure 9. The development of the Robot Components Database

Figure 9. shows the work with the database: the calculations, the record inserting and revoking, the database reviewing etc.

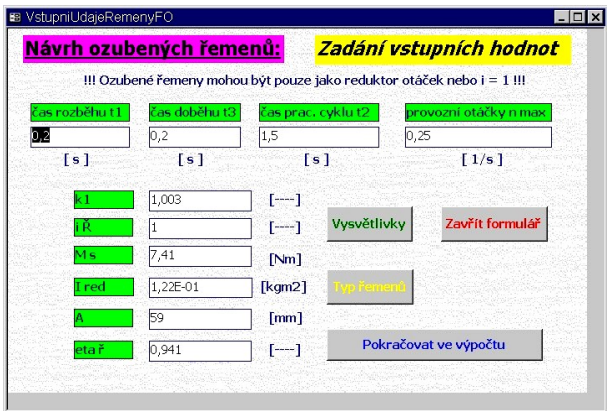

Figure 10. The development of the Robot Components Database – the work with database

Figure 10. shows the work with the database for the indented belt calculation as the component of robot joint.

3.5 Development of the robot mathematical models

One of these models is the robot movement model based on the robot kinematics analysis and synthesis. The analysis of the robot movement (as the multiply of matrixs) is possible also to use for the robot kinematic accuracy counting - we can use for it P-vector. This accuracy of the robot end-effector is possible to transform to the accuracy of robot joints (for example for the gear boxes choosing etc.). The synthesis of robots us enables the computer robot servodrives control etc. [2]

3.6 Specification of rules and regularities for the robot development and design - examples:

a) Series (arithmetic, geometric)
b) Module conception
c) Parametric design
d) Theory of technical hereditary,
e) Mathematical, physical formulas etc.,
f) Tradition and knowledge in the world and also at us in the field of:
- robot design,
- robot control,
- robot application etc.
g) Interdisciplinary and multidisciplinary approaches etc.
h) Technology of design (these problem are solved in the grant of our Ministry of Educatin on the topic Technology of design and Retrofitting, head Kolibal, Z.) etc. [3], [10], [11]

3.7 Expert system for special robots development is based on:

a) the databases of robots and components development,
b) the knowledge bases for robots design, components choosing, joints design, robots control etc.
c) the expert system control mechanism development,
d) the dialogue interface development (menu, questions, specifications, recommendation, limits, graphic INPUT/OUTPUT etc.).

The work with the developed robot expert system:
1. Question: Specify the robot technology?
2. Answer for example: For painting.
3. Specification of robot parameters for this technology (the loading capacity, position accuracy, work trajectory, work space, velocity etc.).

4. Expert system recommends some of robot kinematic structures for this technology (it is developed). The choosing is made base on the developed database of industrial robots.
5. Optimalization of the kinematic structure based on the technical parameters of robots, their joints and economy (it is developed).
6. The decomposition of the robot parameters to the robot joints and then to the robot joints components (it is developed).
7. The choosing of the components for robot joints - it is based on the developed database of components, that enables also the components canting etc. (it was developed for the electrical servodrives, harmonic drives, belt drives, epicyclic gears etc.).
8. The robot design from joints and arms (it will be developed).
9. The design of the robot movement program for this developed robot.
10. Simulation and testing of the robot movement for the technology etc.

In this time we have solved the analysis, synthesis and simulation of the 6 axes robots in C++ language and we are working on the universality of these programs for the robot expert system. We have worked out also the program for the robot design drawing transfer from AUTOCAD (DXF files) to the surrounding C++ for the robot simulation.

4. CONCLUSION

Advantages from the robot expert system using are the documentation of the robot design field at TU Brno, the availability and reliability of the expertise for the robots design, systematic and system approach to this field, economical approaches and acceleration of robots development and possibility of robot modifications for technologies - for example for construction technologies, for mechanical engineering technologies etc.
This expert system based on the C++ programs, AUTOCAD design and Microsoft Acces databases enables also the virtualization of robots design in the philosophy of the world research globalization.

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