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VOICE RECOGNITION IN ROBOT CONTROL –TEACHING STAND

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Summary: *Programming robot PLC controller through voice recognition system has been presented. The purpose of this project is a development of a robot control voice protocol allowing the robot to work on its own, non-computer aided, once the programming process is completed. The computer system is equipped with a voice recognition module connected with the communications module which communicates directly with the executive module or is used for programming and managing the sequence of movements.*

Introduction

A new stand has been developed to be used for teaching purposes; it is based on the PR02 robot of 1979 equipped with an upgraded control system of 2001 based on MicroSmart series PLC controller by IDEC Izumi. It is supposed to be a system which is beyond the presently existing solutions of this type. A development of many modules has been planned. Some of them are to be implemented directly in the controller and others in the associated computer system.

The voice command recognition system consists of CSLU Toolkit software (Open Source) and Tcl/Tk script language command interpreter (Open Source) operating on a PC equipped with a sound card in full-duplex mode for Microsoft Windows. The hardware is additionally equipped with a microphone with noise reduction. Speech signal transformation is on-line.

Description of the plant (manipulator) controlled

The plant controlled, as an example of voice recognition system application, was PR02 industrial manipulator made by MERA-PIAP equipped with a control system, upgraded following own design, based on PLC controller by IDEC Izumi.

PR02 industrial manipulator is a piece of equipment whose mechanical part for manipulations has been built from modules which execute movements and rotations about a few axes. All those components are driven by compressed air. The actuators are cylinders and reverse pneumatic motors. The movements of modules are controlled with three- and five-way valves and electropneumatic diverter valves. The ranges of movements in respective

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modules are set by mobile end stops. The speed of movements of respective modules is set by adjustable pneumatic resistors which are components of the supply system for each module. Basic mechanical components of the robot are given in Fig. 1.

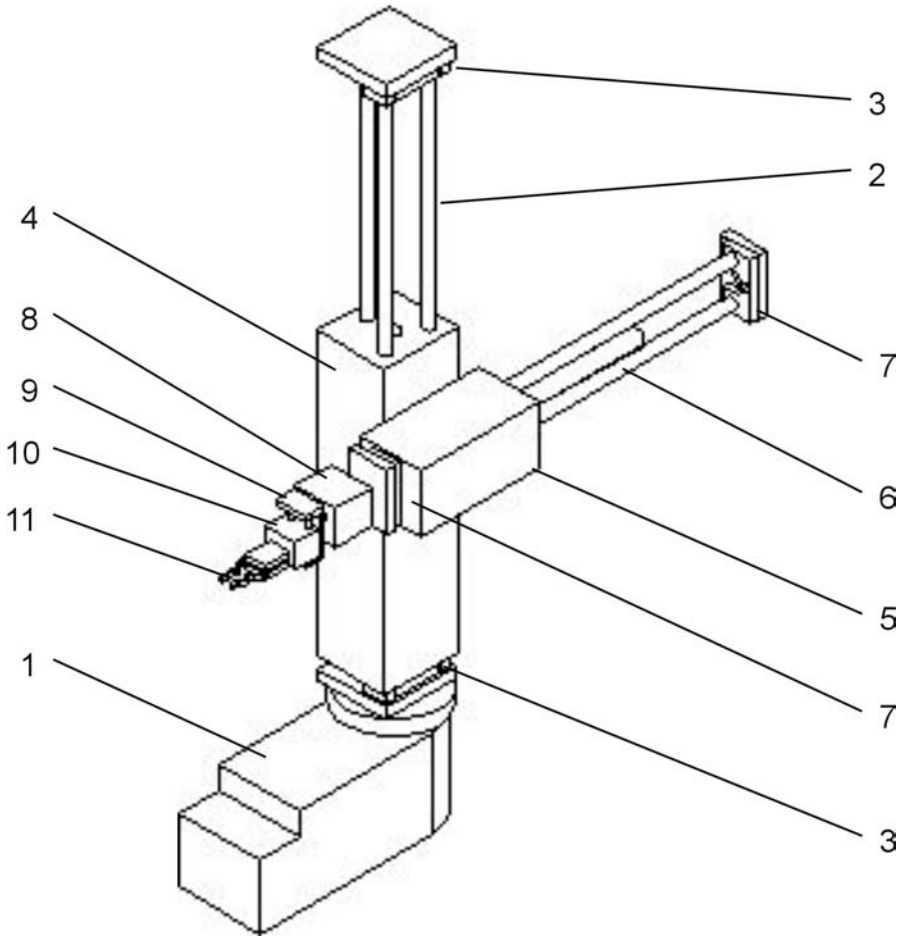

Fig. 1. Robot diagram

Mechanical robot components:

1 – base with rotary motor,
2 – vertical columnway,
3 – vertical columnway end stops,
4 – vertical column with cylinder,
5 – horizontal column with cylinder arm,
6 – horizontal columnway,
7 – horizontal columnway end stops,
8 – mounting of manipulator with rotary motor,
9 – manipulatorway,
10 – grabway with cylinder,
11 – grab.

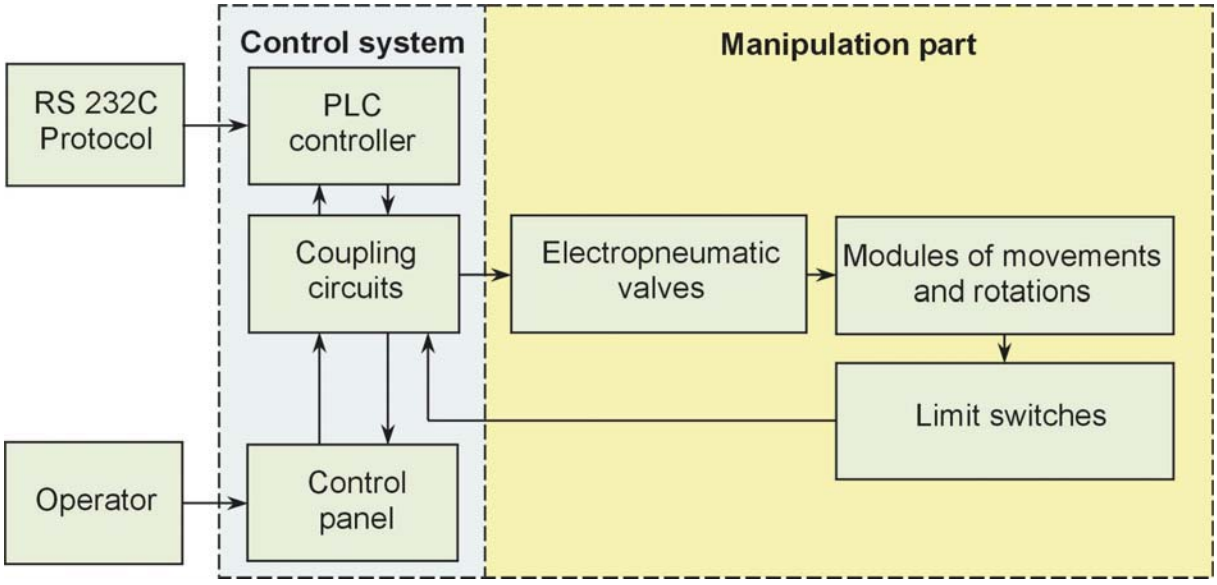

Fig. 2. Block diagram of PR-02 robot

The robot is a discrete object based on binary information. The feedback between the robot and the control system is executed based on limit switches (Fig. 2). The robot control system makes manual control possible with the control panel as well as allows for operation in the automatic mode with PLC controller master function. The feeder system and coupling circuits are also components of the control system. The control algorithm can be stored in the PLC memory or transferred from a peripheral unit by a serial port following the RS 232C standard. MicroSmart controller programming is done in a graphic form as the so-called ladder diagram (LAD) from the dedicated software WindLDR ver.4.10 by IDEC.

Voice recognition environment description.

The voice command recognition system consists of CSLU software and wrapper in a form of Tcl/Tk program language. CSLU programming provides basic structures and tools for the development, testing, and use of interactive language systems, combining voice recognition functions, the functions of colloquial language understanding, speech syntheses and face animation technologies. The toolkit provides a comprehensive, effective and flexible environment for the development of interactive language systems used in technology. The programming rule is based on the use of graphic tools.

The software includes the following tools:

- Rapid Application Developer (RAD): a program tool for creating dialog connections between the user and the computer;
- Baldi: animated face to visualize speech;
- Sync Baldi: user's voice recorder for Baldi animated face;
- Festival: English speech generator;
- EasyMatrix: toolkit to analyze data for PSL.

Developing program involves placing application components on the desktop and joining them with lines. The RAD tool panel view with sample components explaining the rules of application development are given in Fig. 3.

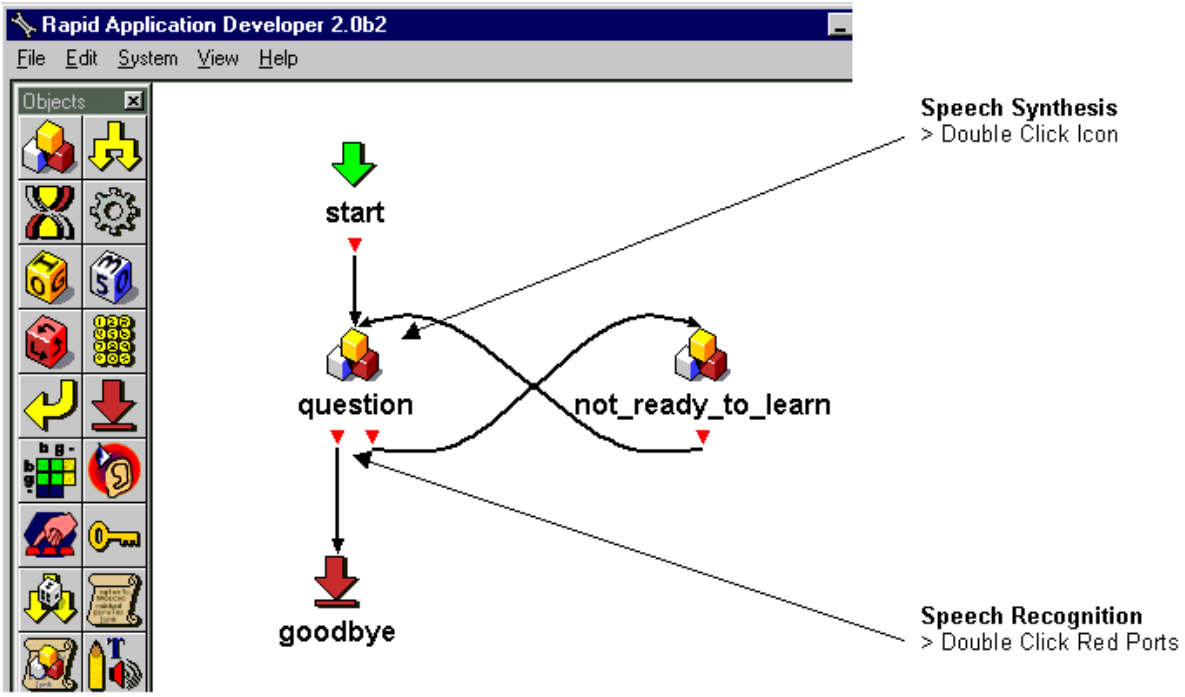

Fig. 3. RAD tool window view to develop CSLU application

The TCL program language belongs to the group of interpretable script languages. It has been written in C language and so it is an extendable language.

Tk toolkit is an extension of Tcl language. It allows for developing and manipulating windows which makes the user's graphic interface. Tcl/Tk language is an interpretable language and to start the application it requires wrappers programs. Indispensable wrappers libraries are available from ActiveTcl programming environment level.

System diagram and operation principles

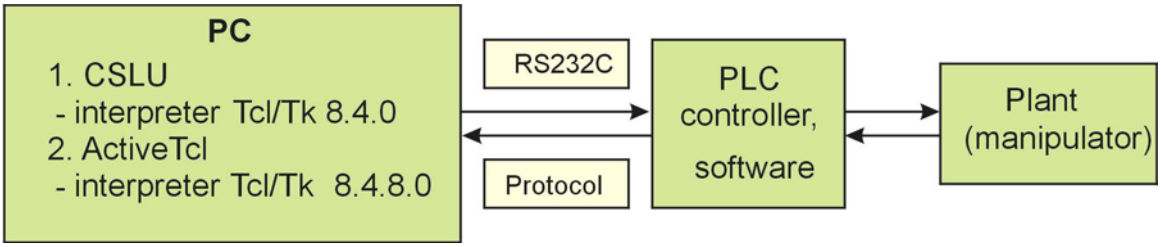

Fig. 4. Functional diagram of the system

The operation of the system is based on the interaction of the autonomic voice command recognition subsystems and plan (manipulator) control. The controller modules include: the executive part controlling the robot movements and informing whether a particular activity has been successfully completed, executive part managing the sequence of movements and the information exchange protocol between the controller and the computer system. The cooperation between both subsystems is possible thanks to the communications protocol which uses ASCII code transmission through the RS 232C serial port (Fig. 4).

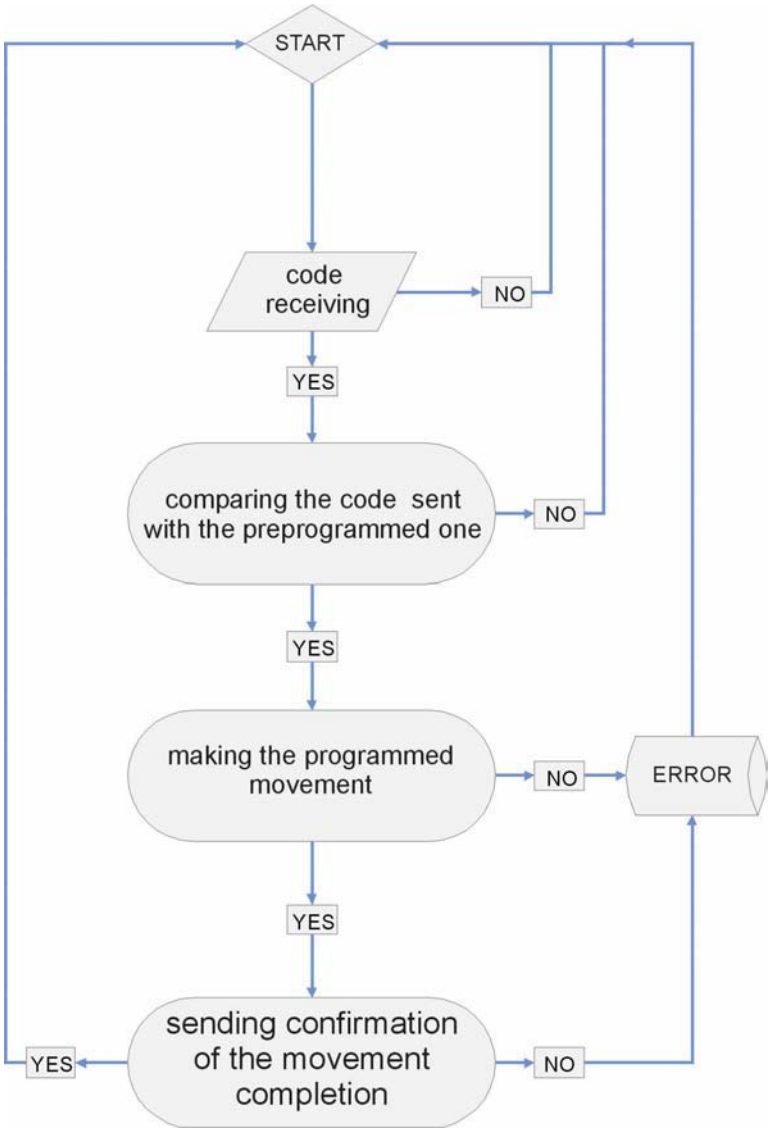

Fig. 5. PLC controller operation algorithm

The PLC operation control program algorithm executes the following tasks:

- Uploading and loading data via RS 232C port;
- comparing the code received with the preprogrammed one;
- coping data into respective memory cells;
- making the preprogrammed movement depending on the code received;
- sending confirmation of the movement completion.

The graph of the algorithm executing the above tasks is given in Fig. 5.

The voice command recognition application makes it possible to control directly all the elementary industrial robot movements, to store a sequence of elementary movements in a form of a file and later call and start the above sequence. The user's interface algorithm responsible for the control of robot operation, programming a sequence of movements, and operations in files is given in Fig. 6.

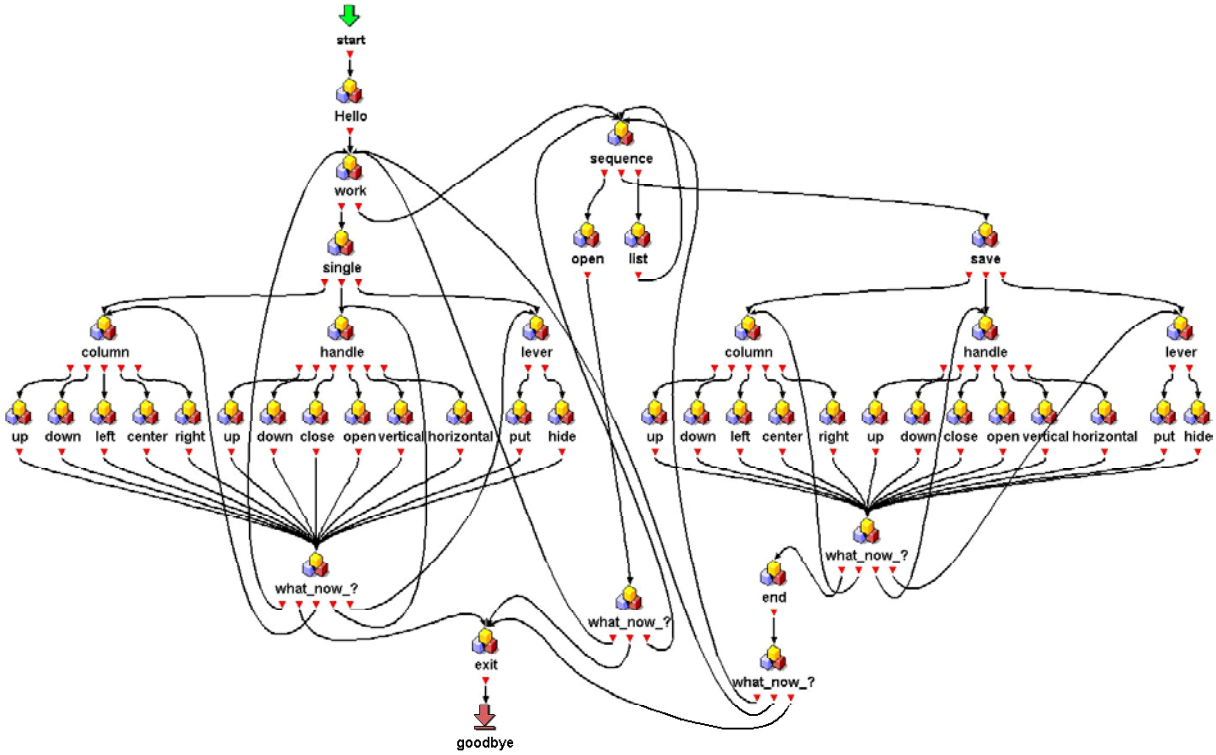

Fig. 6. User's interface algorithm

The user's interface algorithm on the RAD tool level, of CSLU software, makes it possible for the robot to operate in the following mode:

- single: single movements without feedback signals form sensors;
- sequence: complex movements from the sequences of single movements which occurred after one another with a confirmation of completion of respective movements by reading the feedback signal from the sensors.

The 'sequence' mode programming involves the use of operations in files and hence the following possibilities:

- open: loads and executes the sequence from the selected file;
- list: returns the list of available files with sequences;
- save: loads successive single movements to the sequence and saves them to the file.

The sequences of movements programmed are stored as text files, which are created with voice module. There is also a possibility of creating and editing text files from the level of any word processor while sticking to some principles.

The communication between the user's interface application executed in the CSLU voice recognition environment and the robot PLC controller is realized with the communications protocol created with the use of RS 323C serial port. The protocol factors in reciprocal information transfer. As far as the user's interface is concerned, it was developed in Tcl program language.

Apart from the plant control, the communications protocol is also responsible for:

- the analysis of the respective robot actuators states,
- closed-loop feedback,
- diagnostic and alarm procedures.

The following must be fulfilled to make the right operation of the manipulator possible:
– adequate system installation and configuration,
– adequate programming of the sequences, etc.

Conclusions

The aim of the project which has been successfully realized was an unconventional presentation of the potential of the state-of-the-art control system and computer technology using a single stand. The focus was on showing the method of connections and distribution of tasks as a result of limitations of both techniques. The aim has been realized at low costs of the research stand development, which was possible with Open Source software.

Besides the basic tasks, the system also allows for:
– recording the sequences in the files,
– reading and execution of the existing sequences from the files,
– viewing the existing files with sequences.

The system shows a great simplicity and can be easily upgraded. Because the protocol itself and the sequences recording method are based on the ASCII code, it is possible to view, edit, interfere and to control the operation of the system easily.

At present research has been carried out on transferring most of the code to the manipulator controller and on increasing the functionality of the stand by the following elements:
– sequence-oriented rather than movements sequence-oriented optimization module,
– remote communications module for robot programming through a wide area network (including modem connections),
– extension of transmission protocol with autoconfiguration of the computer system for controlling various types of robots.

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