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MECHATRONIC SYSTEM AND VOICE CONTROL

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This paper describes Teach-Robot mechatronic system and algorithm for voice control by simple instructions, that can be used for control of car´s equipment or robotic system control.

Key words: mechatronic system, speech recognition.

МЕХАТРОННА СИСТЕМА ТА ГОЛОСОВЕ КЕРУВАННЯ

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Описано мехатронну систему Teach-Robot та алгоритм голосового контролю шляхом простих інструкцій, який може бути використано для управління обладнанням автомобілів або робототехнічних систем.

Ключові слова: мехатронна система, розпізнавання мови.

PROBLEM STATEMENT. In present time the recognition of spoken speech is highly developed. Communication using verbal speech is the most basic and natural form of information transfer between people. With new communication and information technology it is becoming necessary to use verbal speech for communication with computer.

Most research is focused on using the English language for such communication, however our research is aimed for using the Slovak language.

Research of recognition of spoken speech on our department is oriented on recognition of simple instructions by spectrogram. These instructions are used for car's equipment control such as GPS, radio, air-conditioning or robotic system with embedded systems.

For control with simple instruction are selected Teach-Robot. Mechatronic system Teach-Robot is angular arm with 5 axles and 6 DC-motors (Tab. 1). Teach-Box provides manual control of Teach-Robot and provides communication between Teach-Robot and personal computer (Fig. 1) [1].

EXPERIMENTAL PART AND RESULTS OBTAINED. From decription of Teach-Robot mechatronic system and from the requirement of voice control, following slovak voice commands were selected:

– Vľavo, Vpravo for horizontal rotation of step motors M2 and M6;

– Hore, Dole for pulling and retracting the arm by using step motors M3, M4, M5;

– Otvor, Zatvor for opening and closing the robotic hand by step motor M1;

– Stop for stopping the motion of specified step motor;

– Štart for beginning of voice control session;

– Koniec for setting the robot to its default position (Home – all step motors are in their default position) and for ending the voice control session;

– numerals JEDEN, DVA, TRI, ŠTYRI, PÄŤ a ŠESŤ for selection of step motors or setting the step;

– KROK and numeral – setting the step of selected step motor from 1 to 6.

These 16 short commands are enough for basic voice control of Teach-Robot mechatronic system.

Each step motor is controlled by different number of impulses, therefore for each step motor, KROK has different number of impulses (Tab. 2). KROK-1 is the smallest rotation of step motor – just one impulse. KROK-6 is the biggest rotation – half of the possible pulses of the current step motor M1 to M6 [2].

Table 1 – Moving specifications

Meaning	Motor	Number of pulses	Angle
grip of gripper	M1	70	60°
rotation of gripper	M2	130	200°
wrist up/down	M3	420	90°
rotation of upper arm	M4	420	90°
rotation of lower arm	M5	350	80°
rotation of body	M6	700	320°

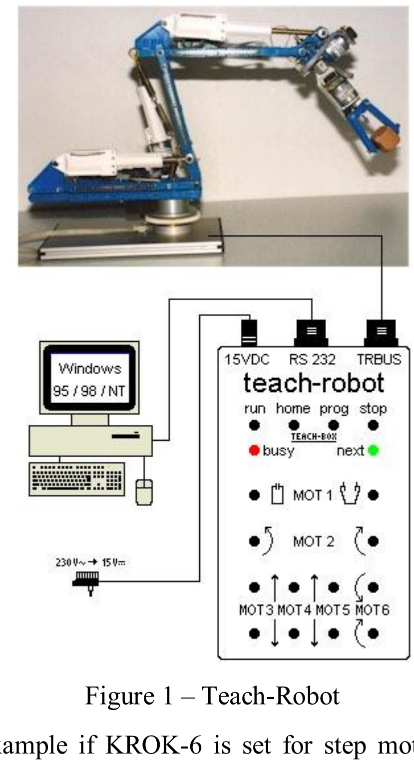


Figure 1 – Teach-Robot

For example if KROK-6 is set for step motor M6, according to table 1 and 2, whole robot rotates by

135 degrees in specified direction, except it reaches final position (beginning or maximum).

Table 2 – Specification of KROK-x constant of amount of pulses for each motor of Teach-Robot mechatronic system

Motor	KROK-x [number of pulses]					
	1	2	3	4	5	6
M1	1	5	7	10	14	35
M2	1	6	13	18	26	65
M3	1	10	21	42	84	210
M4	1	10	21	42	84	210
M5	1	10	35	50	70	175
M6	1	10	35	100	140	350

Teach-Robot has following construction constraints (apart from final position which has to be considered for any kind of control):

– step motor M5 influences the M4 motor, which cannot reach its final position, unless the M5 moves the bottom arm from beginning position. If the bottom arm is betwen the final positions, then the upper arm is independent, it can reach both final positions;

– hand can grab object lying on ground level only in case when both bottom and upper arm as well as tilt of the arm is ejected at maximum – final position of M3,M4 and M5 motors;

– information about motor status is gained only when motor is in stable position and is sent sequentially – the information about first motor, then information about next motor;

– more step motors can be in motion if the requirement for change of position of specified motor arrives sooner, than the other motor reaches its specified position;

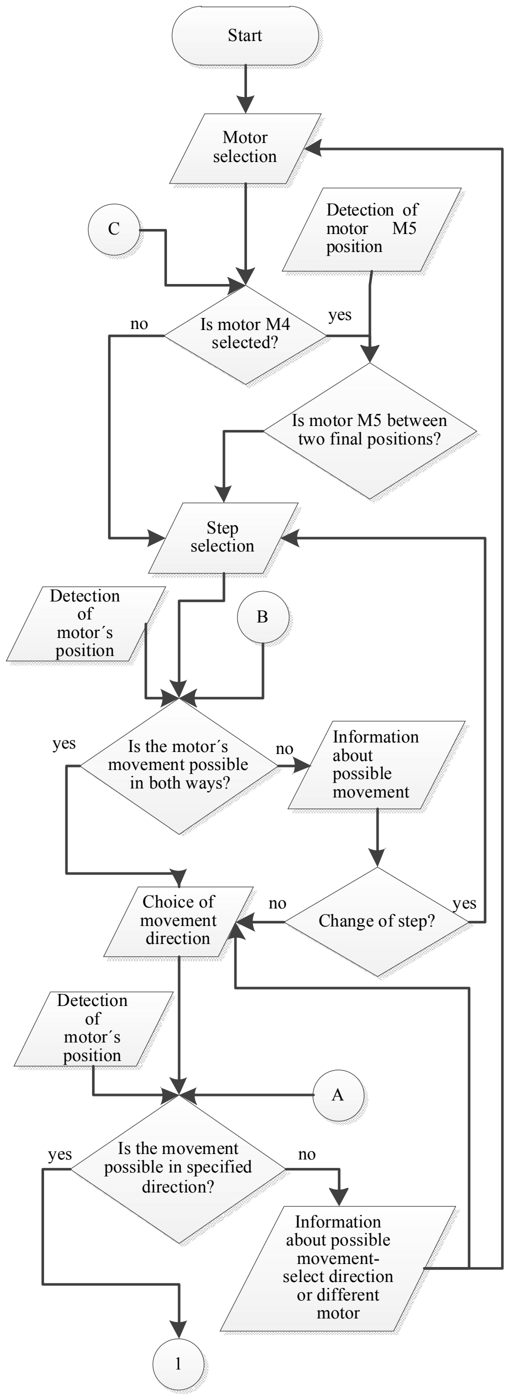
– weight of grabbed object influences the motion [3].

Teach-Box device is used for communication between FOX Board developer system and Teach-Robot controlled system. This communication is realised via RS-232 serial port by 9600 bps speed. Duplex communication is used for controlling, commands are sent to Teach-Box and information about the step motor position from Teach-Box is received.

Algorithm of control (Fig 2) takes into account the construction properties and the neds of voice control. When started, Tech-Robot is in default position – the initial testing command RESET is performed which sets all step motors M1-M6 to default position.

The voice control begins with selection of step motor M1-M6 by numerals JEDEN (One), DVA(Two), TRI(Three), ŠTYRI (Four), PÄŤ (Five) or ŠESŤ (Six). Step motor M4 is influenced by motor M5, therefore when chooing the M4 motor, the M5 position has to be determined. In case that the M5 motor is not between its two ending positions, the movement of M4 motor is severely reduced. Therefore i tis recommended to choose another motor for control. After the selection of motor, the command KROK (step) and numeral (JEDEN, DVA, TRI, ŠTYRI, PÄŤ or ŠESŤ) is spoken. KROK1 for smallest movement and KROK6 for the biggest movement. After the motor´s position is determined, it is needed to determine whether the motor can be moved in both directions by specified step. As was mentioned before, each of the motors M1-M6 is controlled by two directional commands. Motors M3-M5 by command HORE (Up) and DOLE (Down) and motors M2 and M6 by VĽAVO (Left) and VPRAVO (Right) and motor M1 OTVOR (Open) a ZATVOR (Close). If the distance of the motor from its end position is lower than the distance from specified KROK-x, then it is not possible to make specified movement.

The operator is notified about possible direction and possible step so he can adjust the step (KROK) or change direction of movement with specified step. After the choice of direction by voice command, algorithm covers the possibility that operator makes a mistake or ignores the warning about possible direction. Therfore, another control, whether the movement is possible is performed.



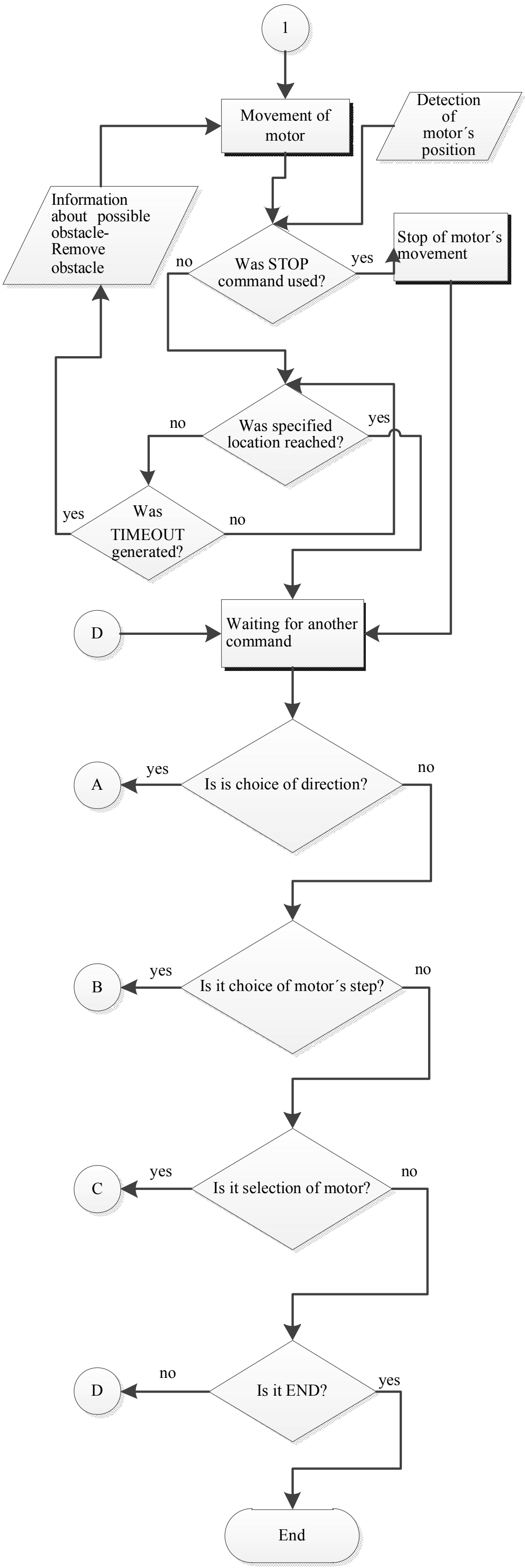


Figure 2 – Algorithm of Teach-Robot control

If it is not possible, operator is informed about possible direction of movement, possible step and/or possible change of step.

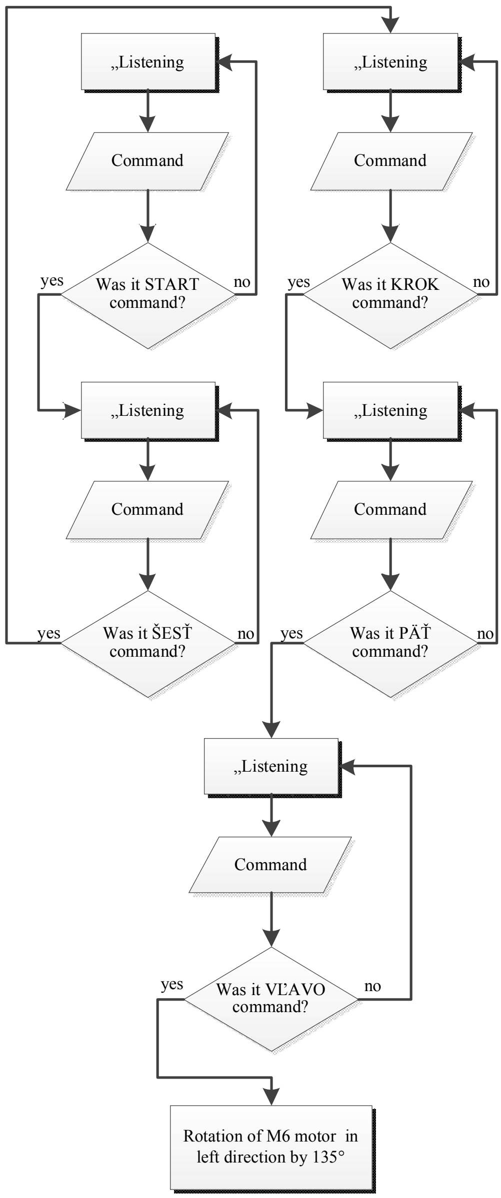


Figure 3 – Algorithm of M6 motor rotation by 135 ° left

If it is not possible, operator is informed about possible direction of movement, possible step and/or possible change of step. If the movement in specified direction is possible, then command for movement to specified position is perfomed. If one or more motors is in motion, then that movement can be stopped by STOP command. After the STOP command, the algorithm detects if the command was used sooner, than the motor reached the specified position.

If the STOP command was used, the robot then waits for another command, or the reach of specified position is determined, for which the TARGET parameter is being utilised. If the specified position was not reached, then the communication was lost or there is an obstacle in the way and operator is informed about the situation. Command for motor´s movement is generated again with time delay.

After reaching the specified position robot waits for another command. Direction, change of step, other motor can be chosen as well as end of control by command KONIEC (End). Command KONIEC performs the RESET command and turns off the voice control [4].

Procedure for voice control of whole body movement utilizing the M6 motor by 135 degrees left from default position is following: (Fig 3) After the ŠTART command, the motor M6 is chosen by command ŠESŤ. For 135 degrees rotation according to Tab.2 KROK-5 has to be chosen. Therefore voice command KROK (Step) and numeral PÄŤ (Five) is spoken. The default position allows movement in both directions by specified step, so the voice command VĽAVO (Left) can be used.

We have chosen spectrogram for our method of speech recognition with embedded systems.

A spectrogram is a time-varying spectral representation (forming an image) that shows how the spectral density of a signal varies with time.

The vertical axis shows positive time towards the up, the horizontal axis represents frequencies, and the colors represent the most important acoustic peaks for a given time frame, with red representing the highest energies [5].

A spectrogram is calculated from the time signal using the short-time Fourier transform (STFT). In our research we have chosen three windows for STFT – Hann, Rectangular and Hamming window.

CONCLUSIONS. For mechatronic system voice control, 16 short slovak voice commands were selected. These 16 commands with algorithm (Fig. 2, 3) are sufficient for basic voice control of Teach-Robot mechatronic system.

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МЕХАТРОННАЯ СИСТЕМА И ГОЛОСОВОЕ УПРАВЛЕНИЕ

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Описана мехатронная система Teach-Robot и алгоритм голосового управления путём простых инструкций, который может быть использован для управления оборудованием автомобилей или робототехнических систем.

Ключевые слова: мехатронная система, распознавание речи.

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