DESIGN AND CONSTRUCTION OF A HEXAPOD ROBOT

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Abstract: In these days most robots are powered by wheels or tracks. I'm developing and building hexapod, a walking robot with six legs. Hexapod moves by steps in several configurations. This paper describes robot construction and shows some ideas about walking algorithms.

Keywords: hexapod, walking robot, servo-motor driver

1. INTRODUCTION

Hexapod is a six-leg walking robot, which has no wheels and moves only with walking [1]. Basic construction facts about material, electronic parts and engines will be placed in the first part of this paper. In the second part some ideas about walking algorithms and servo motor controling are described.

2. CONSTRUCTION

For the construction of the robot was chosen building kit Merkur. Each leg is powered by three digital servo motors. Robot has 6 legs each with 3 degrees of freedom. The third degree allows walking aside. Robot construction is shown on Figure 2.

2.1. MCU AND ELECTRONICS

The heart of the robot is an Arduino board with ATmega2560 MCU, which controls other peripherals such as LCD display, sonars, SD card, Xbee or servo driver. It runs program in C language. The remote control is provided with Xbee serial line from a computer. Scheme is on Figure 1.

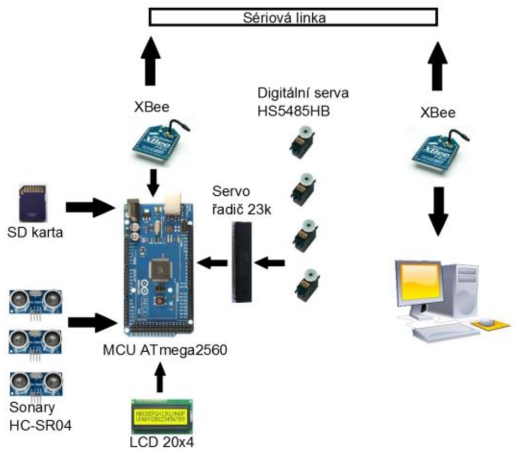

Figure 1: Scheme of electronics.

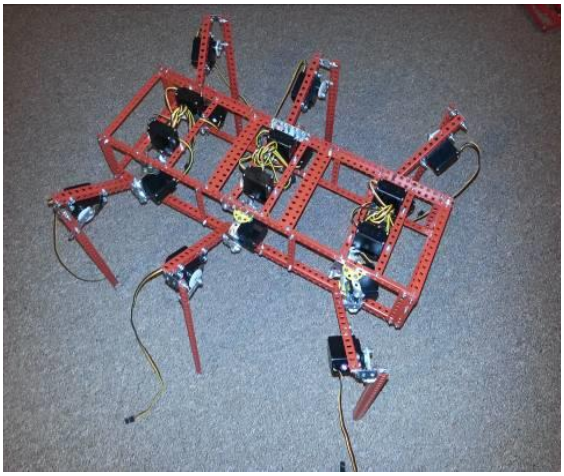

Figure 2: Robot construction.

2.2. DIGITAL SERVO MOTOR AND SERVO DRIVER

Servo motors were chosen for the propulsion system, due to their advantage of simple use. Servo motors are driven with a PWM signal with pulse widht from 1 ms to 2 ms and period of 20 ms [1]. The robot has 18 servo motors so a servo driver is used [2]. The driver communicates with MCU through serial line. The MCU sends commands as two byte code. First byte identifies servo motor and the second byte carries the angle. Digital servos can be programmed (e.g. speed or direction), which was useful to avoid need of software speed control.

2.3. POWER SUPPLY

Power for the robot is provided by two LiPo 11.4 volt battaries. This voltage is regulated to 6 volts with switching regulator LM2576T-ADJ, one for twin servo motors and to 5 volts to supply power to MCU and other electronics.

2.4. LEG CONSTRUCTION

Leg consists of three servo motors. First allows rotational move, second allows vertical move and third allows move aside. Two servos can be seen on Figure 3 (rotational servo is missing).

3. WALKING ALGORITHMS

The robot is powered by 18 servo motors, each leg with three. When motor is given a signal to move, the motor immediately reaches its maximum rotation speed and leg is moved. This behavior is problematic because when it happens, robot is accelerated too fast and its one step is rather a jump. To avoid this problem, leg must be moved harmoniously. So at the beginning the motor is turning slowly and accelerates to a maximum speed in steps. Then it‘s running at maximum speed for some time and slows at the end. This is presented in folowing Table 1:

Time [sec]	Angle [deg]	Time [sec]	Angle [deg]
0.0	35	1.0	220
0.1	40	1.1	215
0.2	45	1.2	205
0.3	65	1.3	185
0.4	95	1.4	155
0.5	125	1.5	125
0.6	155	1.6	69
0.7	185	1.7	65
0.8	205	1.8	45
0.9	215	1.9	40

Table 1: Servo motor angle in time.

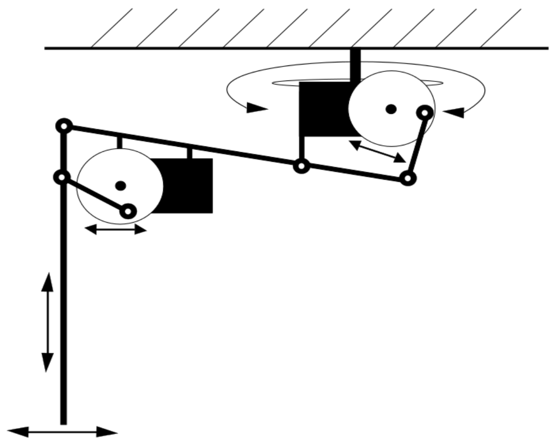

Figure 3: Leg construction.

The angle can be expressed by following polynomial:

$$y = 31.681x^{6} - 377.44x^{5} + 1658.1x^{4} - 3245.9x^{3} + 2637.4x^{2} - 537.24x + 54.827 \qquad (1)$$

Equation (1) shows polynomial, which represents dependence of servo angle in time. The polynomial comes from the graph (Figure 4) as its trend.

3.1. SERVO SYNCHRONIZATION

The graph (Figure 4) shows dependence of the angle on time for one leg. Leg rises (purple), then leg is moved forward (blue) and put down. Third servo (yellow) is not used during walk forward, but allows walking aside. The moves are equal, but are shifted for half period (1 second). Legs are divided into two groups. The first group consists of right front and rear leg and left middle leg and second group consists of left front and rear leg and right middle leg. Legs in same group move together. When group one is forward and down, group two is backward and up. As group one is moving backward, group two is moving forward. Simply the group one and two are shifted for half period of the step cycle.

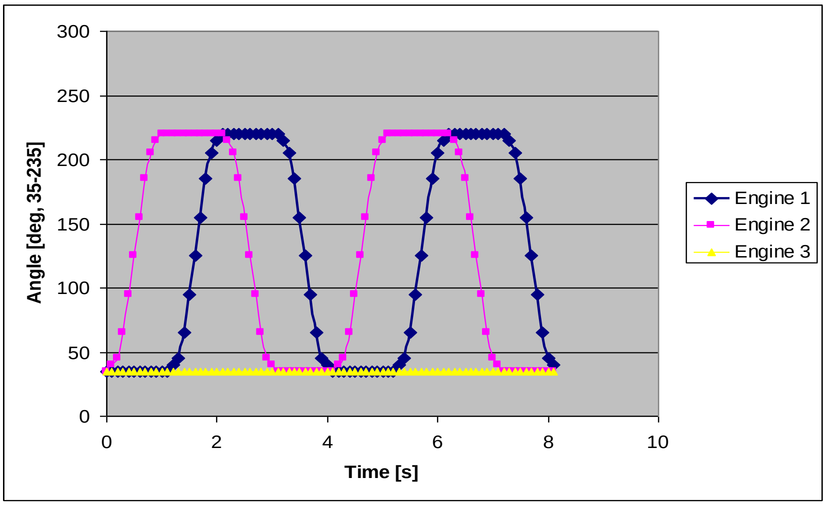

Figure 4: Graph of harmonic motion.

3.2. IMPLEMENTATION

The MCU sends 10 commands per second to the servo driver to achieve harmonic motion of all 18 servo motors. There is a special structure to store commands called calendar, which is cycled through. If the MCU time is equal with start time of first entry in calendar, the command is executed and servo driver sends signal to servo motor.

4. CONCLUSION

Robot is constructed from Merkur kit. Legs are powered by 18 digital servo motors – 3 servo per leg. MCU communicates over serial line with servo driver. Legs are moved in precise order so robot moves forward, backwards, and walks aside or around. Several features must be added such as odometry or temperature sensors for voltage regulators. There is vision the robot will be able to climb stairs. The legs will be equipped with force-sensitive resistors to recognize ground.

ACKNOWLEDGEMENT

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