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Balancing of the anthropomorphous robot walking

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Abstract
Anthropomorphic robots are designed a human environment operates: buildings and structures, cabs and etc. The movement of these robots is carried out by walking which provides high throughput to overcome natural and manmade obstacles. The article presents some algorithm results for dynamic walking on the anthropomorphic robot AR601 example.
The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

Modern requirements for robotics working in conditions of accidents and emergencies are very complex, so the anthropomorphic robots have to work in human existence environment with the tools and apparatus people adapted for [1]. DARPA projects of the US Ministry of Defense announced a contest (DAPRA robotics challenge) of the best robot design are able to move cross-country, climb stairs, use regular electric tools and drive vehicles. Recent developments in the nuclear power plant "Fukushima" has shown the necessity to use robots for disaster. This defines the high requirements for stability of walking anthropomorphic robots and anthropomorphic with cargo [2].

Creating a walking robot - a task required solving many interrelated problems including the problem of motion simulation. Walking anthropomorphic mechanisms have a large number of freedom degrees and their motion described by complex equations [3]. For development of algorithms and software traffic management, we offered to consider complex controlling robot walking as a set of simple patterns or patterns of movement developed by analogy with conditioned and unconditioned reflexes like implemented steps of human. In the paper presents results of development of the not-supporting leg pattern moving for a predetermined path and stabilize the robot actuators of supporting leg.

To achieve this goal highlighted two problems. The first subtask - moving the not-supported feet of anthropomorphic robot of a parabolic trajectory by a predetermined distance. We assume that the motion of a parabolic trajectory, or "stone's throw" is more keep in terms of energy [4]. The second subtask - providing static stabilization of the robot while standing and the committed step. We consider a plane-parallel movement of the legs in the robot plane of symmetry.

Introduce the inertial reference system: the x-axis - is parallel to the Earth's surface in the direction of movement of the robot, Oy - perpendicular to the surface of movement and the Ox axis vertically (Fig. 1). Position the hip (OA) and tibia (AB) about plane xOy defined angles α and β. From foot

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coordinates (p.B) we need to find the angles α and β at each time.

Moving a robot feet is made of a parabola described by the equation:

$$y = \frac{-4h}{L^2} * x^2 + \frac{4h}{L} * x \quad (1)$$

where, L - step length, h - step height.

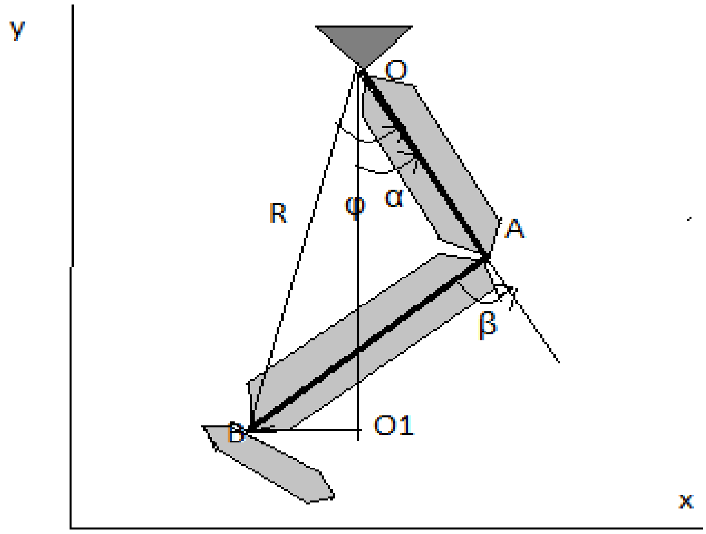

Fig.1. Robot leg geometric scheme

The distance between the hip and the knee, as well as between the knee and shin are (OA = AB = l2 = l1 = 280 mm);
From geometrical scheme in Fig. 1, we find:

$$R = \sqrt{(X_A - X_O)^2 + (Y_A - y_O)^2} \quad (2)$$

$$\phi = \arccos\left(\frac{l2^2 - l1^2 + R^2}{2R * l2}\right) \quad (3)$$

Then find the angles value:

$$\alpha = \varphi - arctg\left(\frac{OO_1}{O_1C}\right) \quad (4)$$

$$\beta = 180 – 180 - 2*\varphi = -2 * \varphi \quad (5)$$

The path of the not-supported leg were built in Octave software [5].

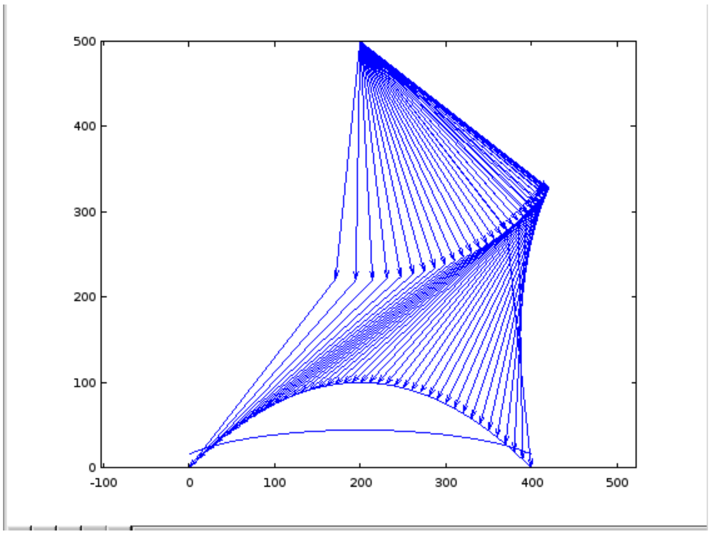

Fig.2. Moving not-supported leg on a parabolic trajectory.

Software was written for working of this movement pattern on the AR601 [6]. According to the given values of the length stride (L), the step height (h) and the time step of one feet (T), built the path of the not-supported robot leg, one of which is presented below:

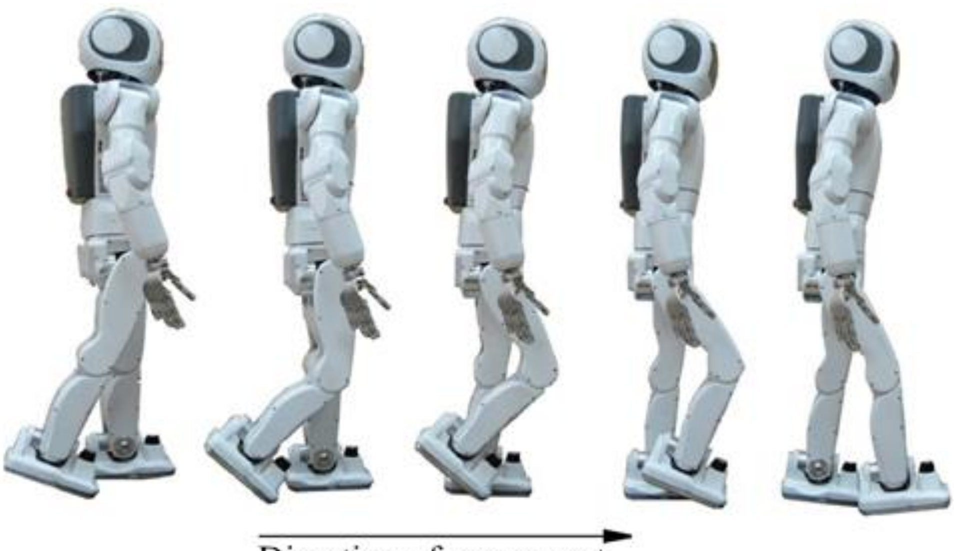

Fig.3. Moving not-supported robot leg on a parabolic trajectory.

To measure the deviation of the anthropomorphic robot AR 601E of the vertical use forces and moments strain gauges placed near the feet joints. It species are represented in Fig.4.

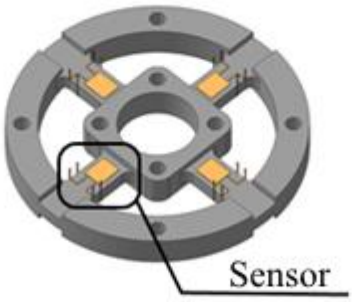

Fig. 4. Forces and moments sensor.

We can detect inclination of the robot by calculating the difference between the values of the pair of opposing sensors. For that reason drawn up a calibration table in which a robot angle corresponds to a particular value of the difference foot sensors. It is also define limits of the robot deviation to ensure stability, it was 8 degrees forward fand, 4 degrees backward. Software was written at Python that in depends of the difference sensor value generates a drive control located at the feet and return robot to an upright position after deflection from the vertical longitudinal plane.There is a video showing the performance of the developed method of the robot stabilization.

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