Team Description ARNE

Alexander Iakovlev, Alexei Kritchoun

NE Company,
21, Partizanskaya ul., St. Petersburg, 195248, Russia
Tel. +7 812 303 89 76
{aviak, alexy_kr}@mail.ru

Abstract. This paper outlines ARNE humanoid robot developed by NE Company, St. Petersburg, Russia. ARNE is 123 cm tall, weighs about 54 kg, and has 28 degrees of freedom. Especially for robot arms and legs low-speed brushless DC motors with power 16 and 60 W were developed by NE Company. All robot drives, motion generation and stability are controlled by Motorola DSP56F805 microcontrollers. High-level decision-making, video and audio processing is performed by remote PC.

Introduction

This paper outlines ARNE Humanoid Robot project started in 2001 at NE ("New Era") Company, St. Petersburg, Russia. The name ARNE is abbreviation of "Anthropomorphic Robot of New Era". Two years of research using simulation models and prototype named ARNE-01 have resulted in ARNE-02 creation.

Main research interests are: (1) building the robot with electromechanical drives suitable for the soccer playing; (2) providing stable walking of the robot; (3) implementing integral perception of the robot using vision, acoustic, gyroscope, tactile and force sensor systems; (4) providing complex behavior of the robot, such as navigation in the dynamic environment with obstacles, skills and personal operations in the game, purposeful behavior in the team. Currently appreciable outcomes are obtained in the first and second directions.

Specification

The ARNE-02 robot is 123 cm tall and weighs about 54 kg. It has 28 degrees of freedom: 6 in each leg, 5 in each arm, 2 in each hand and 2 in head.

Electro-mechanical

Main robot body elements are made from polyamide. Trunk carcass to arrange electronic components and joining hardware are made from aluminum.

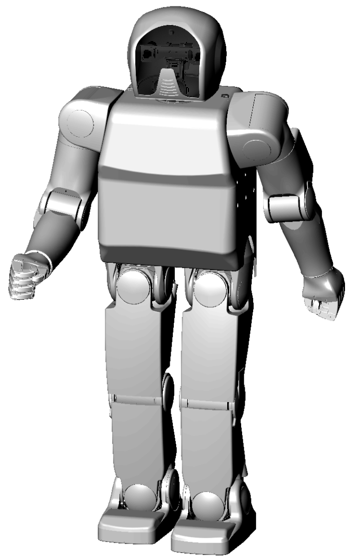

Fig. 1. SolidWorks model of ARNE-02

Especially for robot arms and legs low-speed brushless DC motors with power 16 and 60 W were developed by NE Company. They are used with Harmonic Drive's wave gearheads. Head and hand motors are DC micromotors by FaulHaber DC Motors. Microencoders 2048 impulses per turn and potentiometric sensors are used as rotation degree sensors.

To control robot stability each robot foot is supplied by 4 FlexiForce tactile sensors, robot body has 3 accelerometers ADXL202 and 3 angular velocity sensors ENV-05F-03.

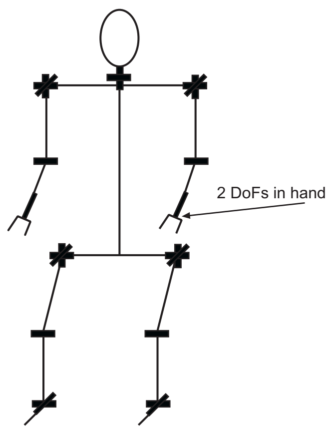

Fig. 2. ARNE-02 kinematic diagram

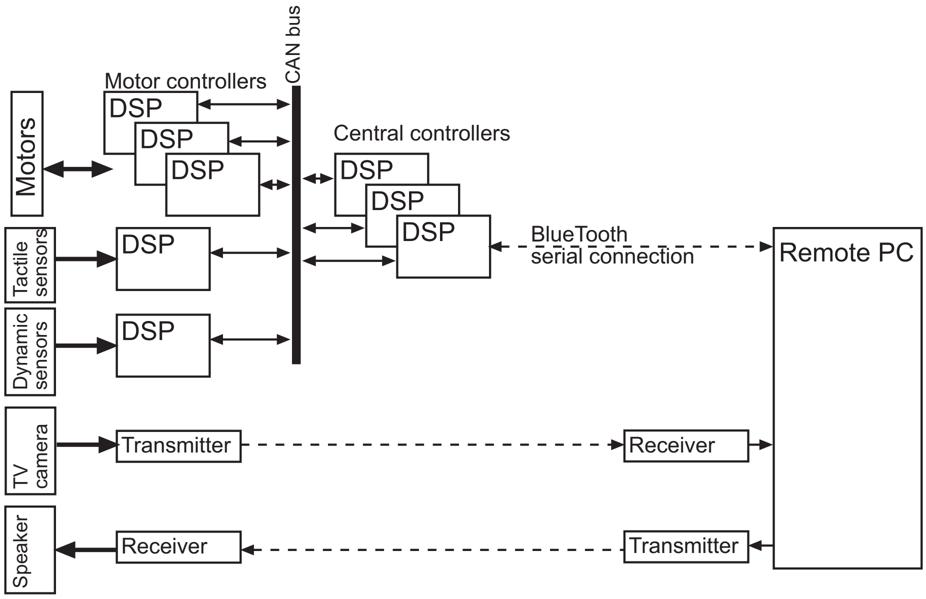

Fig. 3. Block diagram of ARNE-02 control system

Electronics

All robot drives are controlled by Motorola DSP56F805 microcontrollers with IR2132 drivers (each microcontroller controls 2 or 3 drives). Motion generation and stability control is also implemented on Motorola microcontrollers. All of 16 microcontrollers are connected in CAN (Controller-Area Network).

Robot's head has single color TV camera and speaker. Robot has digital speech processor that provides several diagnostic speech messages. In the case of malfunction, robot reports by corresponding speech message.

At present high-level decision-making, video and audio processing is performed by remote PC. Main Control Module microcontroller is connected with remote PC through RS-232 BlueTooth connection. Analog video signal from camera is transmitted to the PC through radio-channel. In order to provide speech communication with human, speech synthesis program on the PC is used. The speech synthesized by the PC is transmitted to robot's speaker through another radio-channel.

Software

Robot behavior control software consists of 5 levels:

- the lowest level of control provides DoF's drives control software running on drive controllers;

- 2nd level performs robot moves control with a coordinated control of robot body parts by solving Inverse Kinematic tasks;
- 3rd level generates robot gait trajectories and controls robot stability;
- 4th level allows robot to gather information about the world and interact with world objects;
- 5th level provides external robot control and other high-level tasks: execution of beforehand given action sequences, voice command control, direct control by operator, speech synthesis.

The software has following peculiar properties:

Robot stability is provided using special criterion of keeping dynamic mass center in bearing area formed by robot feet. Using of the dynamic mass center allows taking into account static mass center and accelerations of body parts' movement. To calculate the dynamic mass center a special procedure is used. Inverse kinematic problem solving procedure allows robot to execute complex flexible movements using all of the robot's DoFs simultaneously. This is useful for good soccer playing.

Robot vision system is executed on the remote PC. The analog video signal received from the robot's camera is being captured and processing by vision software. The software is based on Intel Open Source Computer Vision (OpenCV) library. The vision system can recognize and detect location of color objects like color markers used for robot navigation in field, or colored ball.

Voice control system is also executed on the PC. It analyzes sound coming from external microphone and can recognize up to 20-30 simple commands like "go forward", "turn around" etc.

For speech synthesis standard Lernout&Haspie and Digalo Windows ASPI speech engines are used. Speech synthesis allows robot to say long messages prepared beforehand or generated by operator.

Conclusion

During development of two variants of robots (ARNE-01 and ARNE-02) and auxiliary systems difficulties of this work became clear. A lot of the information and the practical experience have been gathered. Further problems planned to be solved are:

- integrating the high-level control, vision, speech recognition and synthesis systems from the remote PC into the robot;
- improving movement techniques;
- creating stereo vision system to gather information abut the world;
- improving speech recognition system to be able to recognize continuous human speech in noisy conditions;
- improving vision-based robot control.

We believe that it can help to greatly improve robot performance in soccer playing and other applications.