Humanoid robot AR-600

Evgenii Koriagin[1], Sergey Oreshkov[2], Vladislav Sychkov[3], Oleg Tolstel[4]

***Abstract*— This article describes the hardware design and some of the software of autonomous humanoid robot AR-600. It is a full-sized humanoid robot that can be used in human-centered environment.**

I. INTRODUCTION

One of the main applications for robots in nearest future would be to replace (or assist) humans in dangerous situations and hazardous environments. Another important niche for robots is to help humans in their everyday life: assist in study and research, in housekeeping, in the kitchen, elderly care, etc.

AR-600 (fig. 1), developed by Russian company Android Techniques [1], is aimed to be a multitasking antropomorphic robotic platform that can interact with humans and operate in human infrastructure.

It was designed to have a size of a 14-16 years old teenager. And that was done by purpose. Robot that is a bit smaller than a typical human can be treated with all respect like a younger brother who's trying to help in everyday routine. Looking at the robot from above will lead to a better attitude while communicating with it.

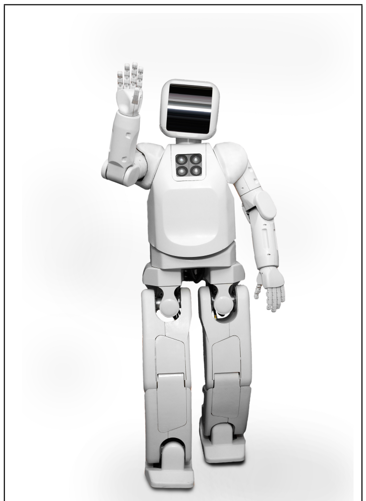

Fig. 1. Antropomorphic robot AR-600.

[1]Evgenii Koriagin is researcher at Intelligent Robotics Laboratory, I.Kant Baltic Federal University, Kaliningrad, Russia `ekoryagin@kantiana.ru`

[2]Sergey Oreshkov is researcher at Intelligent Robotics Laboratory, I.Kant Baltic Federal University, Kaliningrad, Russia `soreshkov@kantiana.ru`

[3]Vladislav Sychkov is CEO of Android Techniques, Magnitogorsk, Russia `info@rusandroid.com`

[4]Oleg Tolstel is head of Intelligent Robotics Laboratory, I.Kant Baltic Federal University, Kaliningrad, Russia `otolstel@kantiana.ru`

Fig. 2. Mimicking device for the robot.

Abilities of robots to accomplish certain tasks autonomously relies mostly on a high level software that implements all the best from the field of artificial intelligence. The other way that allows to use robots now is to make them mimic our moves like avatars. Our AR-600 robot can be controlled by a developed mimicking device (fig. 2). It sends joint angles to robot and gets back force feedback and video stream. With this "suit" on an operator can naturally control the upperbody of the robot and use it to manipulate tools in uninhabitable or hazardous environments (e.g. welding or screwing).

AR-600 is already used in 6 Russian universities as a robotics research platform. Some of the research topics are object grasping and bipedal walking.

This paper describes specifications of the robot, software developed so far and some future work.

II. SPECIFICATIONS OF AR-600

Weight of robot is about 55 kilograms. The overview of kinematic structure is shown in Fig.3, list of DOF is presented in Table 1.

A. Hardware selection

In order to place center of mass as close to hip joints as possible while carrying accumulator batteries in chest cage, aluminium alloy was selected for most inner structure elements.

Maxon motors actuate major joints thought belt transmission with tooth belts and pulley. Elbow and knee joints are shown on fig. 4.

Main controller board built on top of 3 STM 32F107 microcontrollers, minor driver controllers are built on STM 32F103 microcontrollers. Both types use Cortex-M3 ARM cpu and provide softwatre interfaces for hardware interaction.

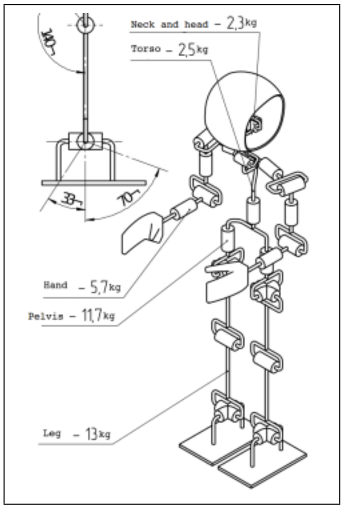

Fig. 3. Kinematic scheme

TABLE I
JOINTS DEGREES OF FREEDOM

	degree of freedom	range of motion	
head	roll	-15	15
	tilt	-20	30
	pan	-90	90
shoulder	pitch	0	105
	yaw	-15	90
elbow	roll	-45	+45
	flexion/extension	0	130
wrist	roll	-45	45
waist	yaw	-45	45
hip	abduction/adduction	-11	20
	flexion/extension	45	-70
	rotation	-20	20
knee	rotation	-140	0
ankle	flexion/extension	-33	70
	abduction/adduction	-20	11

Joint drives are accompanied by two encoders. Main encoder provides absolute position data with quite a broad error rate, supplementary encoder provides relative motion data for more accurate position estimation.

IMU is Analog Devices ADIS 16400, placed just in center of mass to minimize number of transforms required for calculations. There are also CCD camera, speakers and microphone.

There is a frame on the chest, that allows to mount additional sensors like kinect or laser rangefinders, however there no holes in plastic cover for that. There also two small displays in head mount, that mimic eyes and eyebrows.

B. Power

Robot can run on internal LiFePo cells assembly as well as on external power source. Main voltage is 48V, individual parts operate with 6V, 8V and 12V. Autonomous work time depends on many factors, but typically robot can run for a 30-40 minutes.

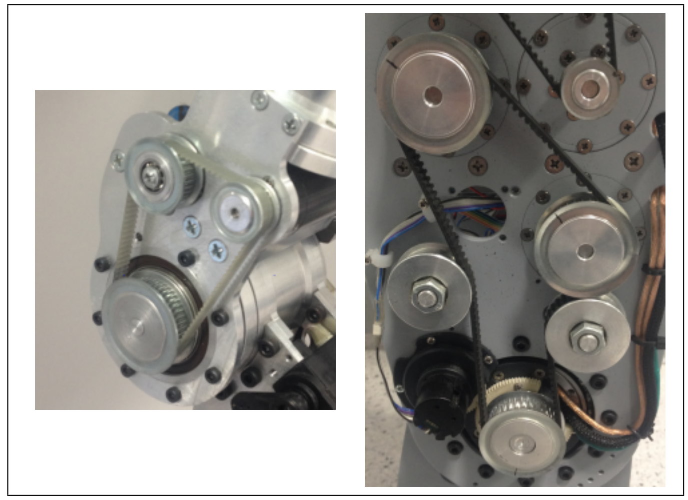

Fig. 4. Elbow and knee assemblies

C. Wrist and palm assembly

Robot has palms with five fingers one opposite to another four. All finger motors are placed in wrist-elbow section, movement of motor translated to finger via system of strings(fig. 5). This system limits wrist rotation, but makes whole assembly significantly lighter. Our current arm is capable to grab objects like tennis ball, Rubik‘s cube or coffee cup, however there are another types of hands under development - palm assembly is under constant development.

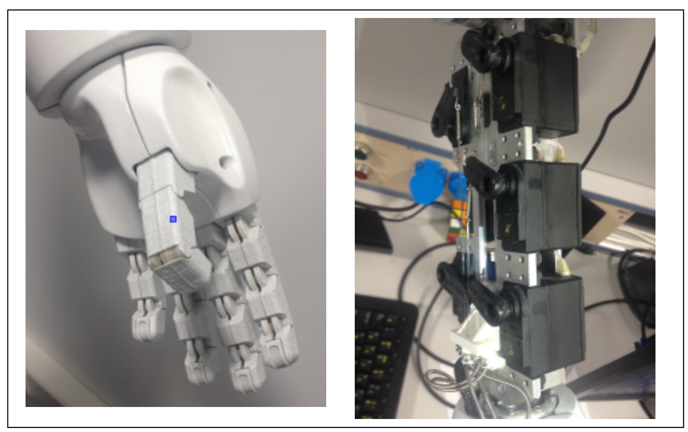

Fig. 5. Palm assembly

D. Control PC and communication bus

Internal communications are built on ethernet. Controller boards are connected via Zigbee interfaces to switch, which governs internal network as shown in 6.

There is also an embedded PC placed in back of robot and connected to same internal LAN. PC is Avalue ECM-QM78 with Intel Core i7-4700EQ CPU and 8GB RAM, capable to carry out performance-demanding sensor-processing tasks. However, there is an option to connect any other PC via ethernet interface.

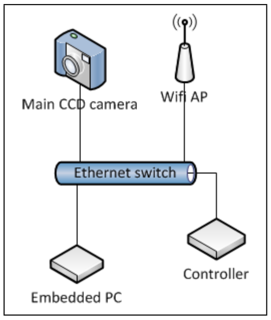

Fig. 6. Internal network scheme

III. SOFTWARE

Main software interface for controller boards is UDP with specially formed datagrams. There two types of datagrams - one is for commands transmission, another returns sensors data. Both UDP streams are independent.

Datagram types encapsulate specific byte array, which encode movement commands and sensors data, so one can easily subscribe interact with robot via standard socket interface libraries.

We already have a set of ROS packages including urdf description for Rviz, moveIt support for whole robot and hand assemblies, gazebo support, neural network and cascade-based vision, speech packets and set of drivers for direct robot interaction.

IV. CONCLUSIONS

This paper presented a humanoid robot AR-600, its hardware design and specifications. Drivers and software that work under ROS framework are also described.

The next generation of the robot, named AR-600E (fig. 7) is expected to be available soon and this will be more powerful, more lightweight, more autonomous system.

Future work includes releasing ROS support packages for public use, development of full-body motion planning with MoveIt (including bipedal walking). Switching from position controller to torque controller is also a priority that will enable more gentle and human-like moves.

We hope AR-600 and his successor AR-600E will be among top humanoid platforms used in robotics research and capable of working alongside with humans.

REFERENCES

[1] Android Techniques. URL: http://en.npo-at.com/
[2] ROS
[3] MoveIt

Fig. 7. AR-600E robot.