Biologically-Inspired Reactive Walking Machine AMOS-WD06

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The six-legged walking machine AMOS-WD06[1] (see Fig. 1A) is a hardware platform for studying the coordination of many degrees of freedom, for performing experiments with neural controllers, and for the development of artificial perception-action systems.

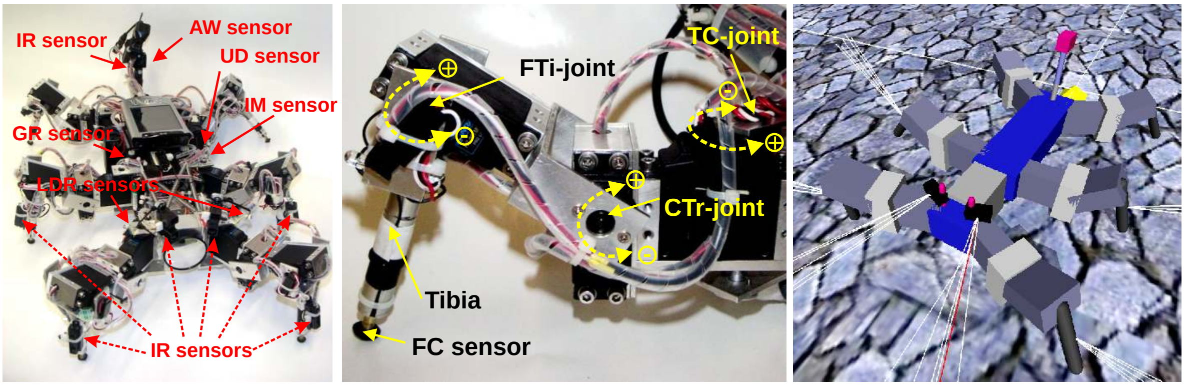
It consists of six identical legs. Each leg has three joints (three DOF): the thoraco-coxal (TC-) joint enables forward (+) and backward (−) movements, the coxa-trochanteral (CTr-) joint enables elevation (+) and depression (−) of the leg, and the femur-tibia (FTi-) joint enables extension (+) and flexion (−) of the tibia (see Fig. 1B). The morphology of this multi-jointed leg is modeled on the basis of a stick insect leg [1] but the tarsus segments are ignored. The length of the tibiae, which are attached to the FTi-joints, is proportional to the dimension of the machine. With a new design of the tibia part, each of them contains a spring damped compliant element to absorb impact force as well as to measure ground contact during walking. The body of the AMOS-WD06 consists of two parts: a front part where two forelegs are installed and a central body part where two middle legs and two hind legs are attached. The front and central parts are formed as narrow as possible with maximum symmetry to ensure optimal torque from the supporting legs to the center line of the trunk and to keep the machine balanced to ensure stability of walking. They are connected by one active backbone joint which can be activated to rotate around the lateral or transverse axis (pitch axis). This backbone joint is inspired by the invertebrate morphology of the American cockroach's trunk (see [2] for details). In addition, a tail with two DOF rotating in the horizontal and vertical axes is implemented on the back of the trunk. This actively moveable tail, which can be manually controlled, is used to install a mini wireless camera for monitoring the environment while the machine is walking. All leg and tail joints are driven by analog servomotors while the backbone joint is driven by a digital one. The size of the walking machine is 30 cm wide, 40 cm long, 12 cm high without its tail. The weight of the fully equipped robot (including 21 servomotors, all electronic components, sensors, and a mobile processor) is approximately 4.2 kg.

This walking machine has six foot contact (FC) sensors, seven infrared (IR) sensors, two light dependent resistor (LDR) sensors, one upside-down detector (UD) sensor, one gyro (GR) sensor, one inclinometer (IM) sensor and one auditory-wind detector (AW) sensor. The FC sensors are for recording and analyzing the walking patterns. Furthermore, they are also used to activate searching reflex behavior if the machine doesn't make contact with the ground at the end of a swing phase. The IR sensors are used to elicit negative tropism, e.g., obstacle avoidance and escape response [3], while the LDR sensors serve to drive positive tropism like phototaxis [4]. The UD sensor is applied to trigger a self-protective reflex behavior when the machine is turned into an upside-down position [3]. The GR and IM sensors are for balancing and detecting a slope. The AW sensor is used to generate wind-evoked escape and acoustic startle response.

The control of this walking machine is kept on a simple but powerful board, the Multi-Servo IO-Board (MBoard)[2], which is able to control up to 32 motors, and which has 36 analog sensor inputs and a size of 125 mm x 42 mm. The MBoard can be interfaced with a personal computer (PC) or a personal digital assistant (PDA) via an RS232 serial connection at 57.6 kbits/s. The testing of neural controllers however was first performed using a physical simulation environment "Yet Another Robot Simulator" (YARS) implemented on a 2 GHz PC with an update frequency of 25 Hz. The simulator is based on the Open Dynamics Engine (ODE) [5]. It provides defined set of geometries, joints, motors and sensors which is adequate to create the AMOS-WD06 in a virtual environment. The basic features of the simulated walking machine are closely coupled to the physical one, e.g., weight, dimension, motor torque and so on. The simulated walking machine with its virtual environment is shown in Fig. 1C. The simulator is precise enough to

[1] Advanced Mobility Sensor Driven-Walking Device.
[2] http://www.ais.fraunhofer.de/BE/volksbot/mboard-content.html.

reflect the corresponding behavior of the physical walking machine. This simulation environment is also connected to the Integrated Structure Evolution Environment (ISEE) [6] which is a software platform for evolving and developing neural controllers. After test on the simulator, a developed neural controller is applied to the physical walking machine to demonstrate walking in real environments.



(a) (b) (c)

Figure 1: (A) The physical six-legged walking machine AMOS-WD06. (B) The physical leg with three DOF of the AMOS-WD06. (C) Simulated AMOS-WD06.

References

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