BigDog robot: a sensor-based enhancement of human capabilities

Steve Taranovich - May 13, 2013

BigDog is a four-legged, three feet tall and three feet long, 240 pound dog-like robot
(Image courtesy of Boston Dynamics)

Boston Dynamics, another great spin-off of MIT, has developed robots that move with the strength and agility of animals, as well as others that can climb vertical walls and a shape-changing robot that can maneuver in tight spaces. All of these devices magnify and improve upon the animal and human capabilities to perform super-human-like tasks.

BigDog

We would like to focus upon one of these creations, BigDog, a four-legged, three feet tall and three feet long, 240 pound dog-like robot that can maneuver up a muddy slope, carry a 340 pound load.
Fifty sensors feed into a computer to help maintain balance and direction of the robot (Image courtesy of Boston Dynamics)

**Go-kart engine**

A 15 hp go-kart engine, comprised of a two-stroke/one cylinder, water-cooled operation, powers a hydraulic system that operates the legs. The leg design was fashioned by designers after large mammal’s natural movements.

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Sensors

Fifty sensors feed into a computer to help maintain balance and direction as well as helping the robot recover in the event of a fall or being forced off its intended course.

Inertial sensors

Inertial sensors measure the attitude and acceleration of the body, while joint sensors measure motion and force of the actuators working at the joints. The onboard computer integrates information from these sensors to provide estimates of how BigDog is moving in space. Other sensors monitor BigDog's homeostasis: hydraulic pressure, flow and temperature, engine speed and temperature.
The robot perceives space with multiple senses (Image courtesy of Boston Dynamics)

In M.Wonders Masters thesis on WordPress, “The body and the senses: the perception of space”, Brian Massumi is quoted as he illustrates how three different layered levels of sensorial perception act in our body to produce our experience of reality. He calls these three levels the **exteroceptive** senses, **proprioception** and interoception. **Exteroceptive** senses are vision, hearing, touch, taste and smell; **proprioception**, observes Massumi, “translates the exertion and ease of the body’s encounters with objects into a muscular memory of relationality”, while interoception, also called visceral perception “immediately registers excitations gathered by the five exteroceptive senses even before they are fully processed by the brain.” These three different layers also correspond to three different sorts of subject-object relations. While exteroceptive senses relate to objects and space in a more unidirectional way, proprioception represents for Massumi the spatiality of the “body without an image” and interoception its temporality. While movement has to be interrupted in order to be captured by the eye, and so it becomes image, proprioceptive sensitivity comes to exist through movement and is therefore nearer to the virtual space that exists between the actual past and the actual future, where the body “becomes”. This is called by Massumi an **event**, and is characterized by pure relationality and is full of potential and transformative energy. Viscerality, that is interoceptive, relates more to time than to space since it is the perception of **suspense** and breaks the process of action-reaction during which our input from the senses is elaborated by our brain and becomes spatially identified.

Homeostasis is the ability of the body or a cell to seek and maintain a condition of equilibrium or stability within its internal environment when dealing with external changes.

**Adapting to terrain**

The onboard computer performs both low-level and high-level control functions. The low-level control system servos positions and forces at the joints. The high-level control system coordinates behavior of the legs to regulate the velocity, attitude and altitude of the body during locomotion. The
control system also regulates ground interaction forces to maintain support, propulsion and traction.

BigDog adapts to the terrain in two ways. It adjusts body height and attitude to conform to the local terrain, and it adjusts footfall placement to compensate for orientation of the robot body and ground plane relative to gravity. The control system leans the quadruped forward while climbing slopes, leans the body backwards while descending slopes, and leans it sideways while walking along the contour line. The control system accommodates shallow to moderate inclines by making slight adjustments to body posture, while it accommodates inclines steeper than 45 degrees by also adjusting the walking gait pattern and using smaller steps. Many of these simulated results have been replicated on the physical BigDog robot, except for very steep climbs where traction in the physical world limits performance.

**LIDAR leader tracking**

[Image of LIDAR leader tracking]

*Image courtesy of Boston Dynamics*

LIDAR follows a human leader with a special vest. (Image courtesy of Boston Dynamics)

BigDog will follow the leader without direct driving and without GPS:

- Leader wears retro-reflective marker
- SICK LIDAR used to locate leader and generate steering signals
- BigDog follows at approximate fixed distance

**The future of BigDog**
The designers are now working on enabling the robot to handle rougher terrain, better self-righting, quieter operation and more autonomy. Stay tuned for more adventures of BigDog!

For more information go to the Boston Dynamics website.