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Design Article

Pleo evolves on four legs and two ARMs

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7/24/2008 4:00 PM EDT

Following in the pawprints of the Sony Aibo, released in June 1999, the Ugobe Pleo dinosaur pet robot is the most recent incarnation of a learning and evolving personal robotic toy. Like the Aibo, the Pleo starts out as an infant animal and evolves over time based on interaction with the owner of the pet robot. Other characteristics of the Pleo similar to those of the Sony Aibo include the ability to mimic emotion depending on human interaction, communicate through gestures and sounds and adapt its behavior based on sensory inputs.

After the Pleo is removed from its colorful, fern-green box, the immediately noticeable difference from prior generations of robotic toys is how lifelike it looks and feels. The hand-painted, texturized rubber skin surrounding the plastic exoskeleton, along with natural-looking eyes featuring irises and opening and closing eyelids, make the Pleo a somewhat eerily real-looking robot.

As important as the skin is in creating a realistic toy, it virtually eliminates any possibility of fixing a broken Pleo. Any defective Pleos that fall under warranty would have to be replaced with a new or reconditioned robot from Ugobe. To maintain the personality of an individual Pleo and pass it along to a replacement, the Pleo comes with both an SD [memory](#) card slot and a USB [port](#) to allow the transfer of accumulated "learning" from one robot to another.

The SD slot and USB port located in the Pleo's underside also allow updates to the proprietary Life [OS](#) developed by Ugobe.

Located next to the memory slot and USB port is the cavity for the 2,200-milliamp-hour NiMH rechargeable battery pack, housing six AA-sized cells.

Sensory overload

After installing the freshly charged battery pack, the quick-start instructions recommend placing a hand on the Pleo's back and gently shaking it. Touch, one of the robot's defining senses, is provided by eight capacitive touch-sensor foils, with four located on each of the front upper sections of the legs, two located on the back and two located on the top and bottom of the head. A light touch is all that is required to solicit a location-dependent reaction from the robot toy.

Complementing the touch sensors is an optical interrupter switch on the bottom of each foot pad that helps prevent the robot from walking off the [edge](#) of a table and causes the robot to squirm when it is lifted off of the floor as all four switches spring into the open position.

Hearing is provided by two microphones located on each side of the robot's head, with audio conversion and [processing](#) handled by an NXP LP2103F [32-bit](#) ARM7TDMI RISC processor. The NXP processor also provides the brains behind the OmniVision OV6650 CIF color [CMOS](#) sensor housed in the snout-mounted camera module. The camera module provides sight for the robot, allowing it to avoid obstacles and detect the presence of something placed in front of the mouth. Underneath the camera module is an IR emitter/detector pair used to communicate with other Pleos. Another IR emitter connected to the sensor board is located in the mouth to detect the presence of food placed in the mouth, which causes a subsequent mouth-closing action.

The primary processor inside the Ugobe Pleo is an Atmel AT91SAM7S256 32-bit ARM7TDMI RISC processor with 256 kbytes of embedded flash memory. It is located on the main board between the front-leg shoulders. Supplementing the memory found in the Atmel processor, and likely storing the Pleo's learning, is a 4-Mbyte Atmel AT45DB321D [flash](#) memory component.

The Atmel ARM7 processor orchestrates the movement of the Pleo through four Toshiba TMP86FH47AUG [8-bit](#) microcontrollers and is the main processor for the Life OS. Two of the Toshiba microcontrollers are responsible for the eight motors providing the locomotion of the Pleo. Between the eight leg motors and the Toshiba microcontrollers are four Fairchild FAN8100N two-channel motor drivers. The remaining two Toshiba microcontrollers and three Fairchild FAN8100N motor drivers control the six remaining motors, which provide the lifelike movement of

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