

Acroban the Humanoid: Compliant Physical Child-Robot Interaction

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- *Compliance* and *semi-passive dynamics* in the framework of humanoid robot locomotion
- Advantages of a *multi-articulated vertebral column* in dynamic semi-passive motor primitives
- Natural playful *child-robot physical interaction*
- The illusion of life: *dynamic movement, touch and the Luxo Jr. effect*

Compliance

- The mechatronic of Acroban allows real-time adjustment of maximal torque enforced by the joints, which makes it close to force control. This allows in particular making **joints compliant** by dynamically adjusting their level of resistance to external perturbations;
- The mechanical structure itself is compliant: Acroban structure includes **springs and elastics** (as energy accumulators), which, together with the backlash of servomotors, make it flexible and thus compliant;

Vertebral Column

Acroban has a humanoid mechanical structure. It has 30 degrees of freedom. In addition to classical joints of humanoid robots, it includes a multi-articulated compliant vertebral column articulated with 5 degrees of freedom. Our aim is to use it in the gait for **robust stabilization in the face of unknown perturbations** as well as to **convert potential energy into kinetic energy** in a semi-passive way.

Luxo Jr. Effect

Acroban provokes spontaneous highly positive emotional reactions, especially in children. Yet, as opposed to most other robots, its morphology is neither roundish nor cute. He has no big eyes. He is just made of metal, and its appearance shows it explicitly. **At first glance, its visual appearance creates low expectation of intelligence and life-likeness. But when it begins to move and one can touch it, its natural dynamics, much more life-like than most other robots, triggers a high contrast and positive surprise.** Life unexpectedly appears out of a neutral metallic object, much as Pixar's Luxo Jr. This is the Luxo Jr. effect.

Child-Robot Physical Interaction

- **Personal robotics** is predicted to arrive massively in our homes in the 21st century, as well as impact importantly our society. Yet, before this vision can be realized, a number of very hard challenges need to be addressed, in particular: human-robot interaction. Most personal robots, from entertainment to assistive robots, will need to interact with humans in a day-to-day basis: this implies that robot should afford intuitive, safe and pleasant interactions, as well as be able to adapt robustly to all unpredicted human behaviours.
- **Joints become tangible interface.** We focus here on physical interaction, which is made possible by the ability of the human to modify the state (joint position) of the robot by a direct physical manipulation, thanks to compliance. In this way, joints become the interface between the robot and the human: They make possible the exchange of analogical information.



Bio-Inspired

The design of Acroban is largely *bio-inspired* and based on the concept of **morphological computation**. The introduction of the vertebral column, but also of compliance follows directly the morphology of animals, and bipeds in particular. The use of compliance as “stabilizing morphological controller” transforms the whole mechanical structure into a distributed system looking for stable configurations. This doing, it relieves the high-level control of movements, which does not have to enforce centralized high-frequency reactions. The mechanical structure ensures a large part of the control.