# Design and Construction of MIKE; a 2D autonomous biped based on passive dynamic walking

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## 1. Introduction

For research into bipedal walking machines, autonomous operation is an important issue. The key engineering problem is to keep the weight of the actuation system small enough. For our 2D prototype MIKE, we solve this problem by applying pneumatic McKibben actuators on a passive dynamic biped design.

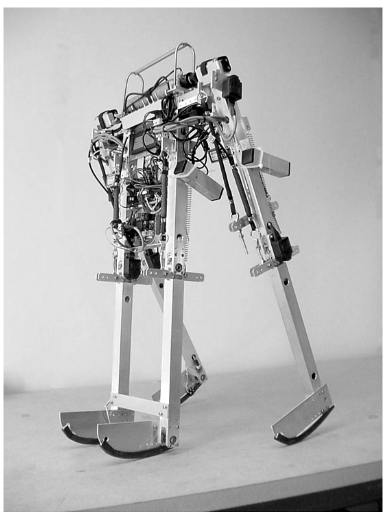

Figure 1: MIKE, see http://mms.tudelft.nl/dbl.

## 2. Prototype design

MIKE's frame was designed as a passive dynamic walker [1]. Previous experiments with a simple passive test machine showed that circular feet with a large radius, rigidly attached to the shanks, provide the best stability (expressed as the maximum step-down that can be recovered from). Mike's feet have a radius of 25 cm, as any larger radius results in stumbling at mid-stance.

To operate on a level floor and to sustain reasonable disturbances, McKibben actuators have been attached to the hip and knees. Because McKibben muscles act like adjustable springs [2], it is possible to apply torque to the joints while still allowing natural oscillations.

The McKibben muscles are powered with $CO_2$ provided by an on board system. The pneumatic system includes a container with 86 grams of $CO_2$ under saturation pressure (5.8 MPa), and two miniature pressure regulators reducing the pressure down to 0.1-0.4 MPa.

The activation pattern is rather simple. Heelstrike is detected by a footswitch. At heelstrike the hip muscles switch stiffness, pulling the (new) swing leg forward. Simultaneously, the knee muscles of the swing leg are released, to be reactivated an empirically determined 400 ms later.

## 3. Results

Mike was activated in stages; the first experiments were done on a slope with 'stepping stones' required when walking with stiff knees. The prototype achieved a stable gait with steps of 0.24 m on a slope of 0.06 rad. Then the knees were activated, and last the hip activation was engaged, removing the need for a slope.

Eventually MIKE walked on level ground with mild disturbances, such as carpet in the laboratory or a fairly even sidewalk outside the building. In these walking experiments MIKE has about the same specific resistance as a walking human being, using about 10 [W] (mechanical and electrical) to pull its 7 [kg] along at a speed of 0.4 [m/s]. On the 86 grams of $CO_2$, MIKE can walk for 3.5 minutes. After a continuous walk that long, the main pressure regulator is deeply frozen due to gas expansion; apparently it is a little undersized for the actual gas flow.

## References

[1] T. McGeer. Passive dynamic walking. *Intern. J. Robot. Res.*, 9(2):62–82, April 1990.

[2] R. Q. vd. Linde. Design, analysis and control of a low power joint for walking robots, by phasic activation of mckibben muscles. *IEEE Trans. Robotics and Automation*, 15(4):599–604, August 1999.