

Chapter 7

Summary and future work

A stable biped robot structure was designed to test a fuzzy balance control and a walking algorithm, based on cubic polynomial interpolation. The biped robot structure was able to walk and to balance. This results are shown on chapter 6. Some videos are also available on at: <http://www.inf.fu-berlin.de/~zaldivar>.

The *incremental fuzzy PD controller* algorithm proposed in this thesis to balance a biped robot can be used by other biped robots with different robot's structures (but with a similar dynamic) and with other degrees of freedom [13]. To implement it, will be only necessary adjust the *incremental fuzzy PD controller* gain parameters.

Thus, the design of new biped robots with different degrees of freedom and different actuators (electronics muscles and faster motors, etc) is an interesting future area of research. A purposeful test could be performed by the incorporation of position-decoders at each robot's motors to a continuous verification of the robot's position. This way, will be a feedback of the real position achieved by each motor and the controller could experiment an improvement on its performance.

In this thesis the *incremental fuzzy PD controller* gain parameters were found by experimentation during the balance and walking test. An interesting propose will be the use of a genetic algorithm to find the *incremental fuzzy PD controller* gain parameters (as an evolution of the best individual, in this case the controller's gains).

At the beginning of the robot's design the incorporation of a gyroscope, inclinometer and force sensors was planed and implemented to acquire some necessaries signals used by the walking balance control algorithm. In the final

robot version, only the force sensors were necessary for the ZMP calculus. As future work, data fusion from the other sensors can be useful to verify and acquire more information about the robot's environment. In such case, the goal of the biped balance robot control could be to achieve an inclination value of zero and maintain the ZMP inside of the support polygon boundary area. Also, a small size sensor selection and efficient actuators capabilities selection (each robot link has a different torque necessity) can be very important in order to save space, weight and energy.

In this thesis a *side to side* balance control was implemented to resolve the biped balance control, to improve this approach, a new balance strategy can be tested with the inclusion of a *front-back* balance control plus the *side to side* balance control.

As a part of increasing the sensory capabilities of the biped robot, a stereo vision system integration with the "Dany walker" is planned. This will allow the robot to avoid obstacles and follow some objects. The vision project is being developed by Erik Cuevas in the PhD thesis *Intelligent vision* at the Freie Universität Berlin.

Also the conformation of a biped robot team to participate on the *Robocup* (world wide robot's competition) is planned. Each biped robot of the team should be able to act as autonomous agents, be able to communicate between other biped robots of the team and plan some group strategies. The participation in this competition is very important to gain more experiences and improve the next biped robot generation at the Freie Universität Berlin.