Bachelor-Thesis: Improving the Motion Patterns of a Hybrid Leg-Wheel Robot using Bio-Inspired Learning Methods

Kai von Szadkowski

26th July 2010

This is a proposal for a Bachelor-Thesis in the International Study Course Biomimetics (IS Bionik) at the University of Applied Sciences in Bremen. The timeframe for this work is 9 weeks, starting in October 2010, with an additional 2 Weeks upon request.

Subject of the Thesis

The hybrid leg-wheel robot `Asguard` has previously been described as being bio-inspired both due to its overall design (approaching the locomotion of insects) and its central pattern generator (Eich et al., 2008). Ongoing work on the robot aims to extend its functionality by installing additional sensory and computer hardware and on this basis implementing intelligent behaviour. However, the `Asguard` remains a complex system particularly challenging in terms of control due to its unusual constructional characteristics, which makes it complicated to apply classic models of motion. It therefore seems promising to investigate the potential of innovative approaches to this problem. This thesis' subject is the application of biologically inspired learning algorithms to improve the `Asguards` efficiency of movement and manoeuvrability, particularly concerning the robot's turning behaviour, which still has a big potential for optimization.

Prior to any tests on the real `Asguard`, simulation is planned to be used to implement the learning methods and check whether they work on the system in this simplified environment. This approach enables for a large number of learning cycles, by far exceeding what would be feasible when directly using the actual robot. Hence, when starting with this work, the first steps are to set up and get familiar with the already existing simulation of the `Asguard` (which will most likely have to be modified). In

parallel, it will be evaluated which particular type of (evolutionary) learning algorithm best fits the problem.

In order to evaluate the reliability of the simulation and chosen learning mechanism, it is worthwhile to first examine a comparably simple task such as walking in a straight line as quickly as possible. If this proves the validity of the approach, the turning behaviour of the `Asguard` will then be tested in the same fashion.

For both cases the definition of useful optimization criteria is a vital element, especially for the more complex turning behaviour. While parameters such as turning speed, energy consumption or occurring vibrations might be obvious choices, it is not immediately clear which, if applied, could yield the best results. Therefore, as the robot's overall design itself is bio-inspired, methods from biology could be applied, potentially leading to a better understanding of the system and its limitations in comparison to biological systems and furthermore providing a reference frame for the evaluation of motion behaviours resulting from the learning process. Especially the analysis of gaits using dimensionless numbers such as the Froude Efficiency could be a useful tool in this context.

Finally, if the described previous stages of the work were successful, the developed behavioural strategies will be applied to the real `Asguard` to allow for a final evaluation or - if time allows - a further refinement of the simulation and learning mechanism.

As the thesis is on a rather tight time budget, good time management will be essential, especially in the beginning, when theoretical considerations as well as setting up the simulation will have to be worked on simultaneously. This first phase should be finished within 3-4 weeks. The mid-section of this work will be dedicated to the actual simulation work, i.e. running simulation cycles, examining the results and refining parameters. This will take at least another 3-4 weeks, while in parallel it is planned to begin with writing text and preparing data for the thesis report. The last approximately 2 weeks will be used to test the results on the `Asguard` system and finally finish the report.

It might further be worthwhile to start with the theoretical work prior to the thesis, so that some necessary tools (such as a literature database or even optimization criteria) are already present at its start. It may also become necessary to use the possibility to request a 2-week's extend of the thesis if problems with the simulation occur.

References

Markus Eich, Felix Grimminger, Stefan Bosse, Dirk Spenneberg, and Frank Kirchner. Asguard: A hybrid legged wheel security and sar-robot using bio-inspired locomotion for rough terrain. In *IARP/EURON Workshop on Robotics for Risky Interventions and*

Enviromental Surveillance (IARP/EURON-08), January 7-8, Benicassim, Spain, Benicàssim (Spain), Online-Proceedings, Benicàssim (Spain), 2008.