$position(t) = A\cos(2\pi f t + \theta) + Offset$

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# *Squid I* – A remote-controlled walking robot

## Developed as part of 31384 - Modular Robotics, 2012


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**Abstract –** This document describes the design and implementation of the remote-controlled walking robot *Squid I*. It is shown that the four-legged robot can be conveniently controlled using an extremely simple control loop and a sinusoidal central pattern generator with a frequency of 1 Hz. However compared to the winning design this robot is four times slower and thus not competitive. Hence it is not recommend for future use.


### Introduction

*Squid* is a four-legged remote-controlled walking robot with six degrees of freedom (Figure 1). It can move in four directions by lifting itself with two legs and pushing forward with the other two legs. The movement is controlled by a sinusoidal central pattern generator. For autonomous mode[1] it has one long-distance sensor in front and two short distance sensors left and right. In the following the program logic is explained and the effect of the position signal frequency on the movement is analyzed.

Figure 1: Squid is walking in the grass.

### Facts

| | |
|---|---|
| Name: | Squid |
| DOF: | 6 |
| Directions: | 4 |
| Sensors: | 1x long distance, 2x short distance |
| Max speed: | 0.13m/s @ 3 Hz |
| Weight: | 734 g |
| Result: | 4th place |

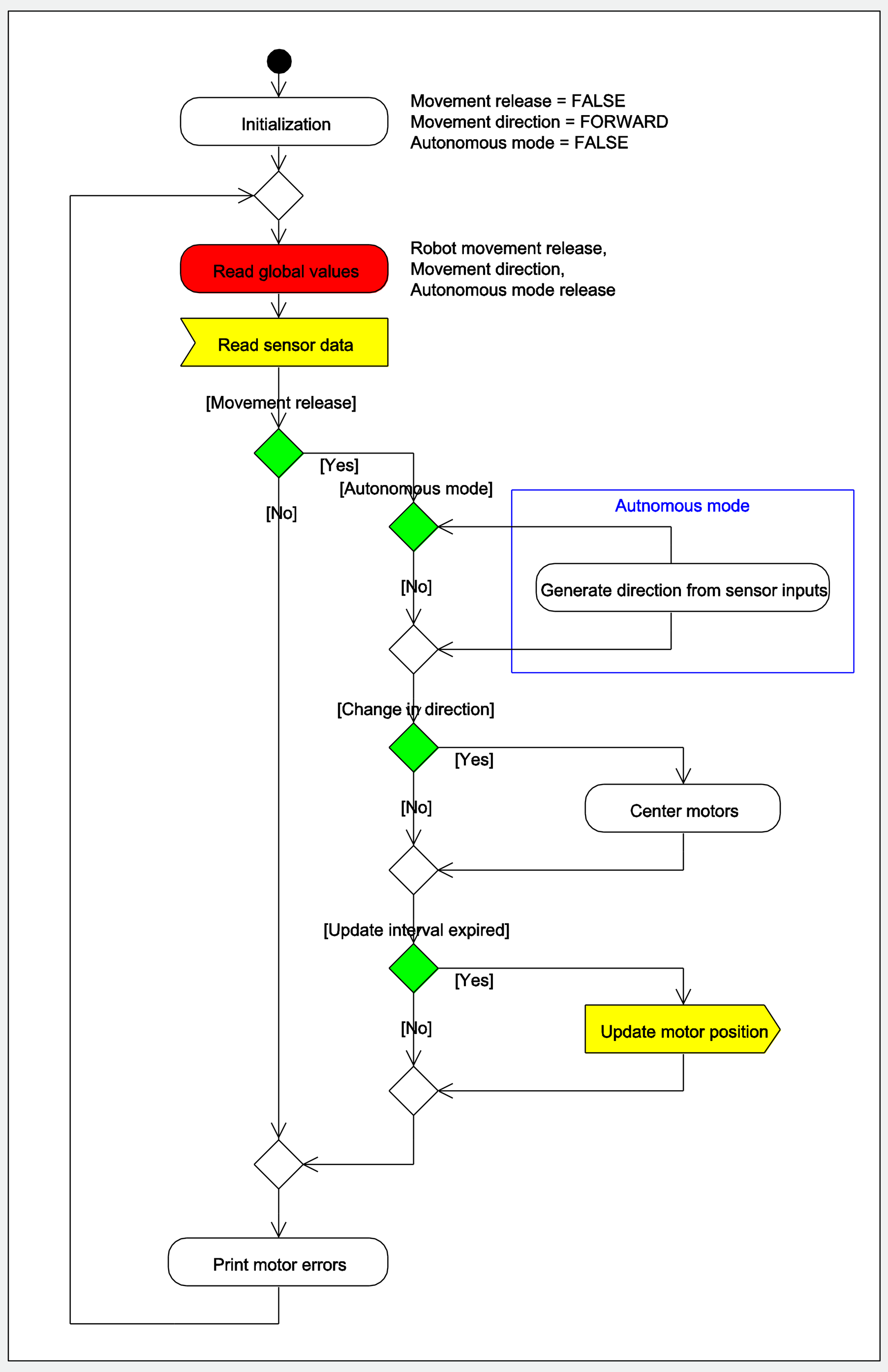


Figure 2: Simplified activity diagram of program logic

### Program logic overview

Figure 2 shows a simplified activity diagram of the program logic. At the beginning the hardware is initialized once. Then the program enters the main control loop. Here global data (e.g. movement release and direction) is copied in an atomic block to local variables to avoid race conditions. Then the sensor values are read[2] and noise removed. In case the autonomous mode is active the movement direction is decided by the sensor inputs. Next, if the direction is to be changed the robot moves in a special center position to provide smooth transition. Finally the motor position is updated using a sinusoidal position generator. It is found that too much traffic on the motor bus can cause connection problems. Thus the position is updated only after a certain interval and for all motors at the same time (broadcast). At the end of each control cycle the motor status is printed for convenience.

### Experiments

From the former section it is known that a sinusoidal signal is used to calculate the motor positions. Thus, the amplitude, frequency, phase shift and offset of the signal has to be determined. The experiment illustrated in Figure 3 shows the total movement time of the robot for a distance of 1.4m in relation to the signal frequency. Clearly the robot is the fastest with a frequency of 3 Hz. Further increase of the frequency let the robot jump uncontrollable and significantly raise the movement time.

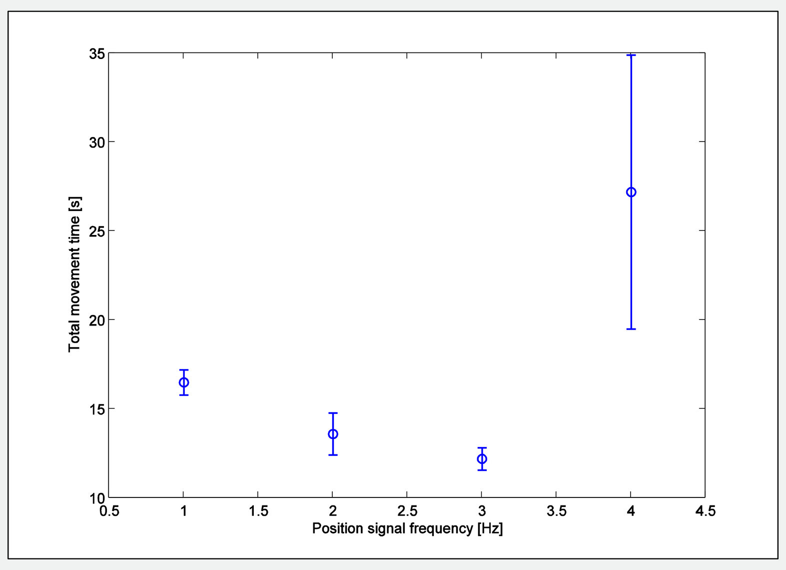


Figure 3: Total movement time of the robot for a distance of 1.4m in relation to the position signal frequency.

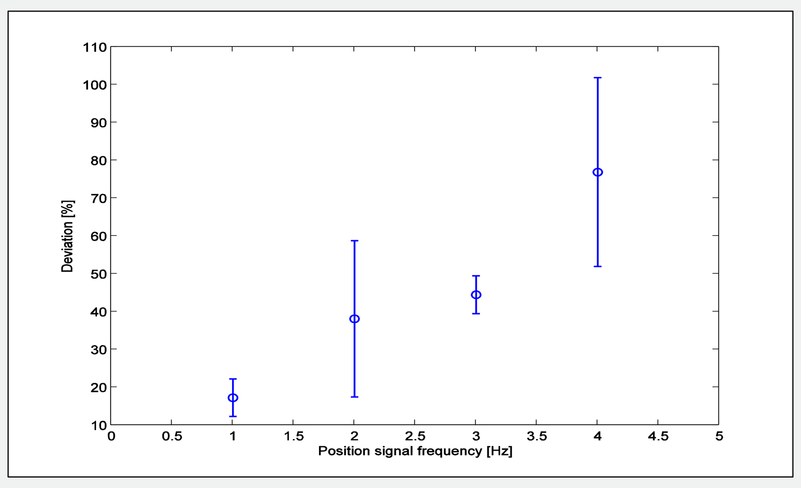


Figure 4: Relative position deviation of the robot after a distance of 1.4m in relation to the position signal frequency.

The downside of running the motors with a frequency of 3 Hz is the position deviation as shown in Figure 4. The higher the frequency, the higher is also the deviation of the robot from its target position. As tight position control is important it is recommend to run the robot at a frequency of 1 Hz.

### Results

The experiments show that a reasonable accurate robot can be achieved by controlling the given design with a sinusoidal position generator running at a frequency of 1 Hz. The robot speed can be increased by 26% up to 0.13 m/s when running at 3 Hz. However the position deviation also raises by 157%.

Compared to the robot design of the winning team with a speed of about 0.6 m/s this robot is four times slower. Thus the design is not recommend for future use.

[1] The autonomous mode is not covered in the paper. Please refer to Dennis Hellner's poster "Squid II – An autonomous walking robot".
[2] The sensor values are not used in remote-controlled mode but are read for convenience anyway.


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