Comparing the effects of morphological variation in locomotion using a salamander-like robot to salamanders locomotor system

Semester Project

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Analysis of the behaviour of the salamander robot
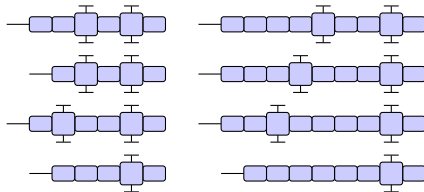

Questions

- How does the morphology and the environment affect the gait?
- What is the optimal morphology?
- Does the robot behave similar to real salamanders?

Background

This project is based on a previous work where the following robot configurations were analysed:
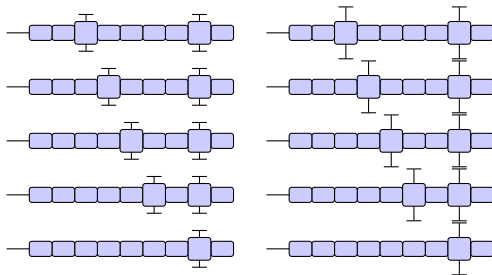

Issues

- Variable robot length
    - Different number of actuators
    - Reduced resolution for short robots
    - Results have to be normalized
- Unknown error of the amplitude

Scheme of improvement

Additional limbs make it possible to use a new set of configurations:

Improvements

- New set of limbs
- Uniform number of robot elements
- Additional robot morphology
- Measurement of the real flexion

Gait control

controllers

- joint angle: $\alpha_i = A_i \sin(2\pi f t + \phi^i_{lag}) + \psi^i_{offset}$
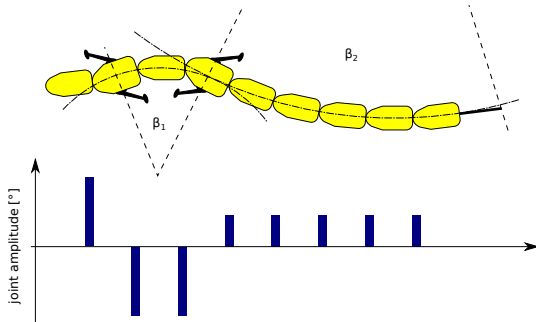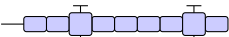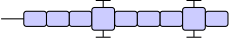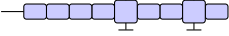- limb rotation: synchronous to the sine controller, $DF = \frac{T_{stance}}{T_{cycle}}$
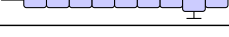
Figure: Determination of the amplitude for terrestrial gaits.

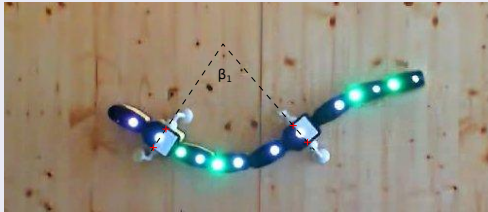|	walking	swimming
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	×	✓
long limbs	✓	✓
short limbs	✓	×
frequency f [Hz]	$\{0.3, 0.6, 0.9\}$	$\{0.6, 0.9, 1.2\}$
bending β_1 [°]	$\{40, 60, 80\}$	—
amplitude A [°]	—	$\{10, 20, 30\}$
number of waves k	—	$\{0.25, 0.5, 0.75\}$
duty factor	$\{50\%, 60\%, 70\%\}$	—

Data processing

There's only one experiment per parameter set.

Tracking system

- Coordinates of the LED's
- Three independent parts are analysed

Manual tracking

The video files have been tracked manually to determine the amplitude for the terrestrial experiments.

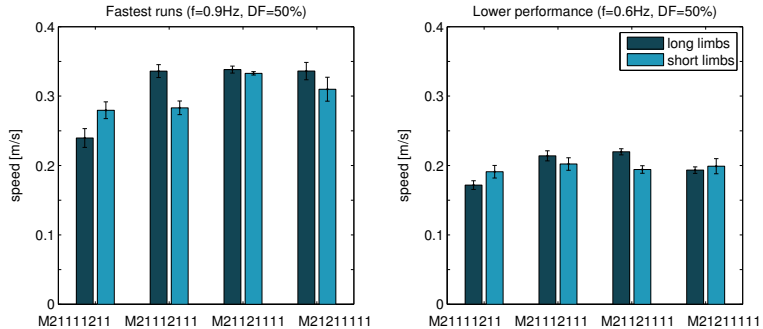Figure: Selected results for walking experiments for $\beta_1 = 60°$.
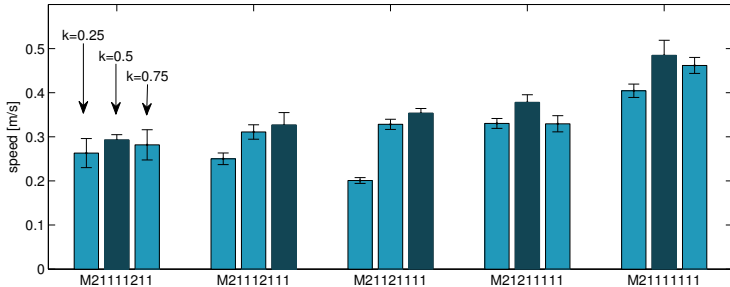
Figure: Selected results for swimming experiments for $A = 20°$.
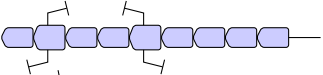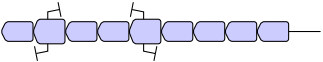
Operation mode	Robot configuration
Walking on land	
Swimming	
Walking and swimming	

Table: Selected robot configuration for different environments.

Comparison with salamanders: indices

forelimb length

interlimb distance

body length
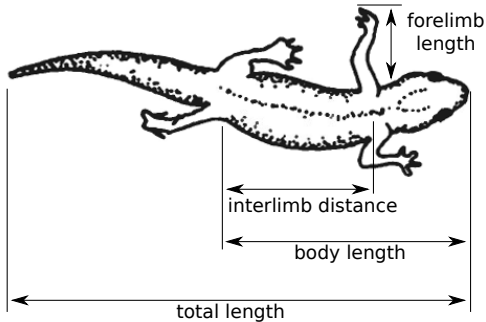
total length
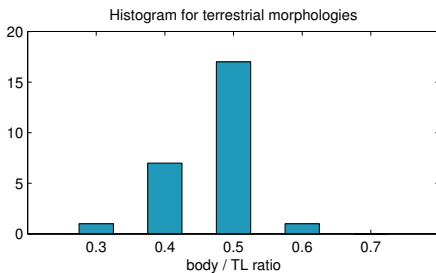
Body proportions

- Hindlimb position: $\frac{\text{body length}}{\text{total length}}$

- Wolterstorff Index (WI): $\frac{\text{forelimb length}}{\text{interlimb distance}}$
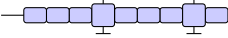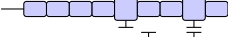
Salamander proportions

Histogram for terrestrial morphologies
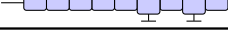
Exemplary species and trend

	Species	body/TL	WI
te	Triturus dobrogicus	0.5	$0.34 - 0.45$
	Triturus cristatus	0.5	$0.45 - 0.6$
	Trend	**~0.5**	**0.3-0.6**
aq	Proteus anguinus	0.65	$0.11 - 0.16$
	Pleurodeles waltl	0.5	~ 0.4
	Trend	**~0.5**	**0.1-0.4**

Comparison

Robot indices

Robot configuration	body/TL	WI short limbs	WI long limbs
	0.7	0.09	0.14
	0.6	0.11	0.17
	0.5	**0.14**	**0.23**
	0.4	0.21	0.35

Salamander indices

Habitat	body/TL	WI
Terrestrial	0.5	$0.3 - 0.6$
Aquatic	0.5	$0.1 - 0.4$

Thank you for your attention!