

# SNAKE-LIKE ROBOTS

## 1 INTRODUCTION

Robotics is rather new field which, without doubt, has endless potential. Skipping the origin of the word “robot”, important figures in this field, or even the first full-fledged robot to ever exist, this short seminar work focuses on bio-inspired robots, specifically snake-like robots.

First let us think about why do people even create robots. There are many various reasons, one of the surely is that the robot meant to help people with labour. It is meant to do the work, which would otherwise be very exhausting, or maybe even impossible for a person to do. It is meant to replace the person in the specific activity. It is certain, that the replacement should be at least as good as the original, if not even better. From a certain perspective, it is the replacement trying to imitate the original and at this point we may say that the fake was inspired by the original, whatever that original might be.

## 2 SNAKE-LIKE LOCOMOTION

In order to imitate the movements of the original, one must first take a closer look the structure of said original. Living snakes are interesting choice for the robot-maker enthusiasts due to their unique anatomy. The aim of this work is not to dig deep into biology, but in short - their bodies consist basically of a long spine and numerous ribs with various muscles in between. What is more interesting are the movements that have been observed and further studied.

### 2.1 Rectilinear locomotion

This type of locomotion is typical for bigger snakes. The trick is in utilizing the abdominal scales and abdominal muscles. This method allows motion in direct path and can be compared to crawler; however, this method somewhat lacks in terms of speed compared to other methods. [1] [2] [3]



*Figure. 1 Rectilinear locomotion [4]*

## 2.2 Lateral undulation

Sometimes called serpentina motion, this method is the most common among the snakes. The method is highly efficient in rocky or similar environments, where various protrusions are abundant. [1] [2] [3]



*Figure. 2 Lateral undulation* [4]

## 2.3 Concertina locomotion

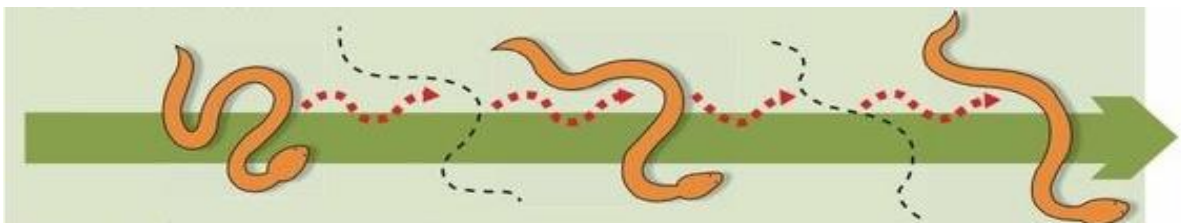
This locomotion consists of series of contracting and “shooting” the snake’s body. While this method offers low traveling speed, it is sometimes necessary. It might be useful for example jumping between tree branches or hunting in burrows. [1] [2] [3]



*Figure. 3 Concertina locomotion* [4]

## 2.4 Sidewinding

This type is unique and is used by snakes living in sandy environment, where any other methods would prove inefficient due to lack of solid support on the surface. [1] [2] [3]



*Figure. 4 Sidewinding* [4]

### 3 SNAKE-LIKE ROBOTS

There are plentiful snake-like robots nowadays and many more are in development in the present. There are differences, be it overall construction, motion method or even power unit. One of the dominant figures in this field Tokyo Institute of Technology classifies all their concepts into 5 base categories. There are few examples listed in each category.

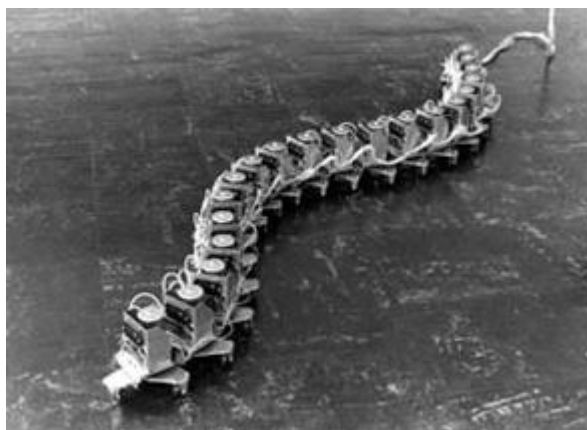
**Table 1** Five basic categories according to Tokyo Institute of Technology [5]

CATEGORY	ROBOT NAME
Active bending joint type	ACM-III ACM-R3 ACM-R5
Active bending and elongating joint type	Slim Slime Robot ACM-S1
Active bending joint and active wheel type	ACM-R4
Passive bending joint and active wheel type	Genbu
Active bending joint and active crawler type	Souryu

#### 1. Active bending joint type

ACM-III (Active Cord Mechanism – III)

One of the first to ever mathematically describe snake-like locomotion was J. Gray in his works in 1946. Japanese professor Hirose Shigeo followed up and in 1972 he introduced ACM-III model, which is dubbed as the first snake-like robot to ever successfully demonstrate snake-like locomotion. [5] [6]



**Figure. 5** ACM-III [6]

## 2. Active bending and elongating joint type

### Slim Slime Robot

The model consists of linearly connecting multiple modules that pneumatically bend and elongate. The robot was designed for manoeuvring in long, narrow pipes. [5] [6]



*Figure. 6 Slim slime robot [6]*

## 3. Active bending joint and active wheel type

### ACM-R4 (Active Cord Mechanism-R4)

This model is basically modification of previous model ACM-R3, which belongs to the 1<sup>st</sup> category. While the ACM-R3 added just the possibility of 3D movement, all movements were just results of bending joints in various patterns. ACM-R4 however has active wheel which further improves overall mobility. [5] [6]

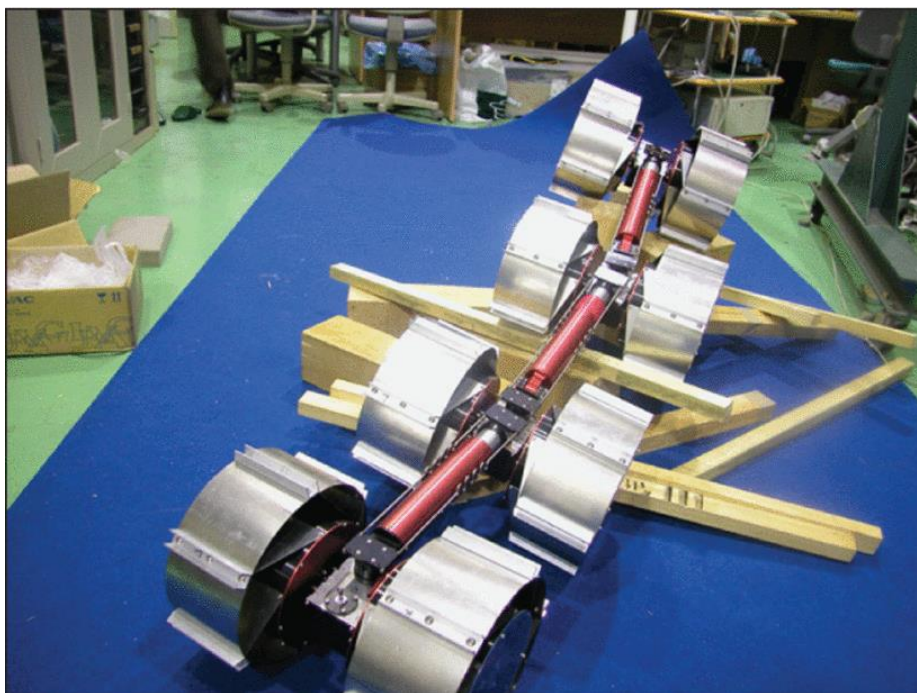


*Figure. 7 ACM-R4 [6]*

#### **4. Passive bending joint and active wheel type**

##### **Genbu**

As the name of the category suggests, the movement is assured mainly by active wheels, therefore is only natural, that the attention should be focused of said part of the robot. The Genbu model was designed to have dominant wheels and joints to passively provide better grip of the surface. [5] [6]



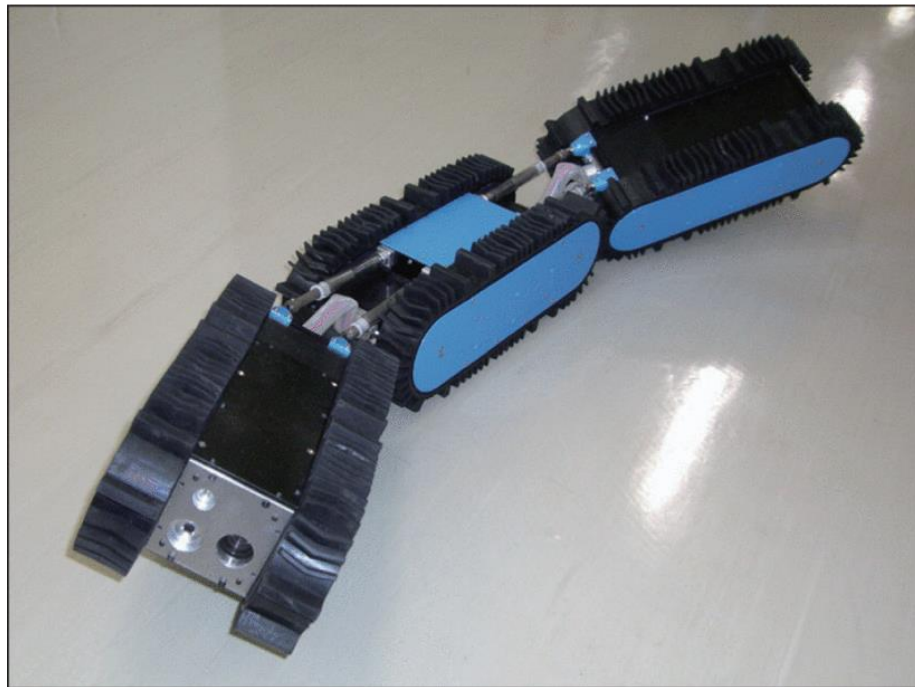
*Figure. 8 Genbu [6]*



## 5. Active bending joint and active crawler type

### Souryu

The Souryu series was developed with the desire to be able to move in extreme environment caused by natural disasters. The following figure shows Souryu-IV which consists of 3 segments each possessing a crawler. The segments are connected via rods which allows slight rotation. [5] [6]



*Figure. 9 Souryu-IV* [6]

## 4 SEZNAM POUŽITÉ LITERATURY

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