# 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 thinks 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. Today we recognize 4 main types.

## 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]

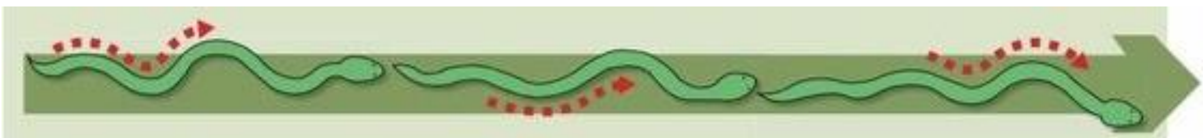

***Figure. 2*** *Lateral undulation* [4]

## 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]

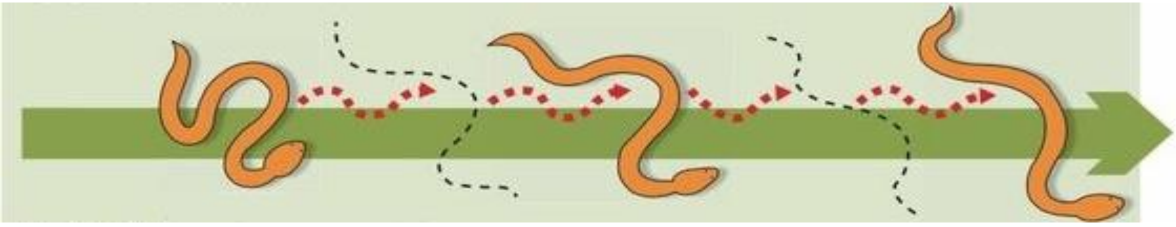

***Figure. 4*** *Sidewinding* [4]

# 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<br>ACM-R3<br>ACM-R5 |
| Active bending and elongating joint type | Slim Slime Robot<br>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]

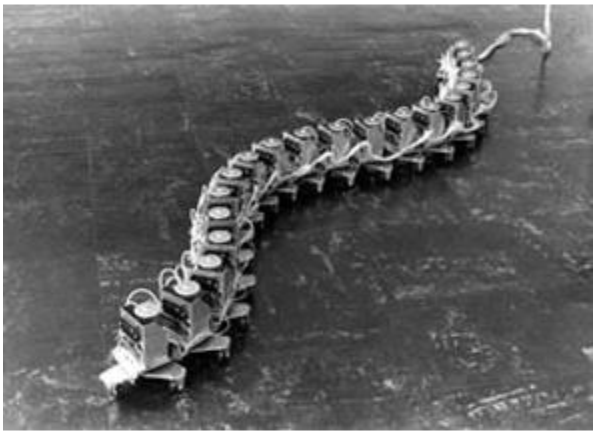

***Figure. 5*** *ACM-III* [6]

## 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 1st 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]

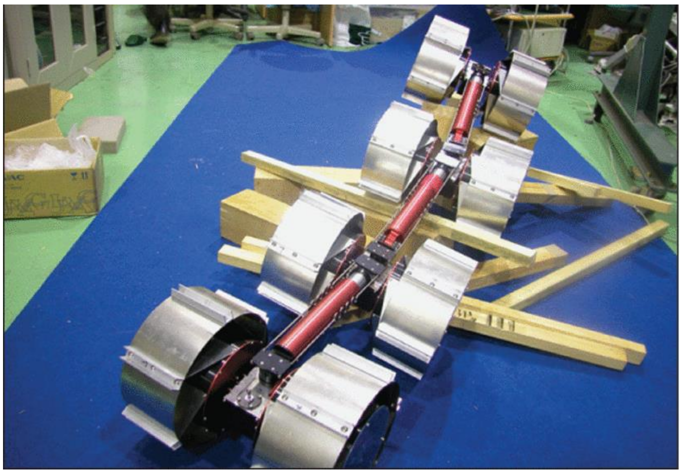

***Figure. 8*** *Genbu* [6]

## 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]

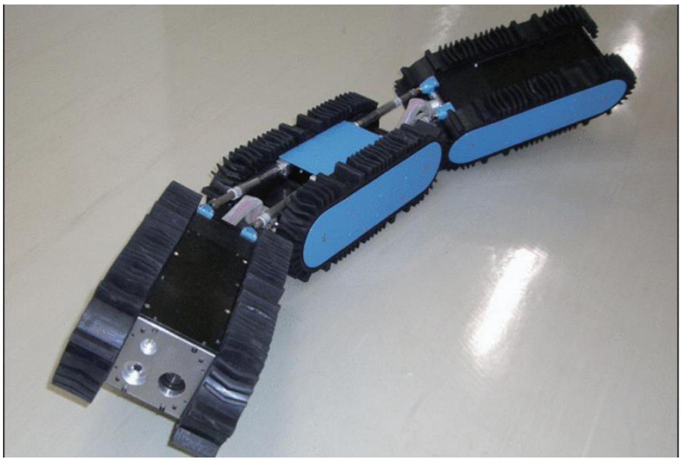

***Figure. 9*** *Souryu-IV* [6]

# 4 SNAKE-LIKE ROBOTS APPLICATION

Many research groups around the world have various goals. There is one goal that almost every group more or less tries to achieve – that is to deploy the robot into the environment where all conventional equipment fails. An example would be sites struck by natural disaster, where all movement would be restricted due to debris and unknown dangers.

September 2017 central Mexico was struck by an M 7.1 earthquake which lasted 20 second, claiming almost 400 lives and injuring over 6000, making it the second worst earthquake of the year. [7] Help from all corners around the world arrived in many forms be it volunteer rescue units, donations, or equipment. Among many, the Carnegie Mellon University from Pittsburgh also contributed with a snake-like robot and a team of operators. The team actively participated in rescue activities in Mexico City, by deploying the robot to two different passages the snakebot was able to provide rescue workers with the feed through the debris, unfortunately without success. Still, the mission provided valuable experience in demonstrating the robot’s capabilities in an actual rescue mission. The snake robot received positive reactions from on-site rescue personnel and Mexican Red Cross even expressed their desire to own such robot in the future.[8]

***Figure. 10*** *Rescue mission in Mexico City* [8]

# 5 CONCLUSION

Snake-like robots have endless potential and can be applied in almost every thinkable field. Be it scouting dangerous or inaccessible areas as a rescue bot or performing surgeries requiring extreme precision, it all comes down to ability to perform desired movements. Thanks to the snake-like shape, the choice of possible movement is practically endless.

Even though we may find snake-like robot in here and there today, the true utilization of their potential is yet to be achieved. It is rather experimental, and not very common; however, the overall progress is undeniable, and it is just matter of time when the snakebots will be truly relied upon.

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