# MECHATRONICS BOOK SERIES SELECTED PAPERS FROM ICOM'01, ICOM'05 AND ICOM'08

**Editors**

Asan G. A. Muthalif
Amir A. Shafie
Momoh J.E. Salami

IIUM Pres

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011


Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

ISBN: 978-967-0225-68-5

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
**IIUM PRINTING SDN. BHD.**
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

# CONTENTS

CHAPTER ONE: Mechatronics System Design and Applications

## CHAPTER TWO: Modelling and Simulation



## CHAPTER THREE: Intelligent Systems

## CHAPTER FOUR: Instrumentation, Dynamics and Control

## CHAPTER FIVE: Machine Vision

## CHAPTER SIX: Speech and Image processing



## CHAPTER SEVEN: Robotics and Automation

## CHAPTER EIGHT: MEMS and Materials

## CHAPTER NINE: MEMS and Materials

## CHAPTER TEN: MEMS and Materials



## CHAPTER ELEVEN: MEMS and Materials

# Investigation of a Novel Type of Locomotion for a Snake Robot Suited for Narrow Spaces

**M. Watanabe, M.R. Khan**

Department of Mechatronics Engineering, Faculty of Engineering
International Islamic University Malaysia, Jalan Gombak, 53100 Kuala Lumpur, Malaysia
mluqmanw@yahoo.com, raisuddin@iiu.edu.my

## ABSTRACT

In snake robot research, one of the most efficient forms of locomotion is the lateral undulation. However, lateral undulation, also known as serpentine locomotion, is ill-suited for narrow spaces, as the body of the snake must assume a certain amount of curvature to propel forward. Other types of motion such as the concertina or rectilinear may be suitable for narrow spaces, but is highly inefficient if the same type of locomotion is used even in open spaces. Though snakes naturally can interchange between the use of serpentine and concertina movement depending on the environment, snake robots based on lateral undulation to date are unable to function satisfactorily in narrow spaces. In undergoing concertina movement, the snake lifts part of its body off the ground to reduce friction; this cannot be reproduced in planar snake robots. To overcome the inability to adapt to narrow spaces, a novel type of a gait is introduced. With slight modifications to the members of the multi-link snake robot, the robot normally developed for lateral undulation is able to utilize the new gait to negotiate narrow spaces. The modifications include alterations to the snake segments as well elements that mimic scales on the underside of the snake body. Scales, often overlooked in locomotion research, play an important role in snake movement by increasing backward and lateral friction while minimizing it in forward direction. This concept provides the basis for movement in the proposed gait. Through kinematic studies the viability of this gait is illustrated.

## 1. INTRODUCTION

Having developed the active chord mechanism to model the movement of lateral undulation [1], Hirose went on to conduct further research on the same type of locomotion [2,3,4]. Numerous studies based on Hirose's work have also cropped up during the years. Initially Hirose used passive wheels on his snake robots, and Saito's research [5] looked as achieving the same locomotion without any such wheels, with the body of the robot in direct contact with the ground. Other variations include the application of the same type of locomotion to different surfaces such as a sloped surface [6] or uneven surfaces [7]. In recent years, Hirose teamed up with other Japanese researchers to develop a 3-D version his active chord mechanism [8]. However, all these works are principally based on one type of locomotion: lateral undulation.

This is not to say that other modes of locomotion have not been studied. Many years back, Burdick developed a model for the sidewinding movement [9], while somewhat more in the recent past a robot was developed based on rectilinear motion [10]. Even different gaits not found in natural snakes have been examined by the likes of Chen [11], where a movement known as lateral rolling is studied. Interestingly enough, studies on concertina locomotion is surprisingly absent.

Coming back to the application of snake movements, the advantages of the serpentine movement has been abundantly demonstrated. The movement is efficient and can be utilized in various environments. There is, however, a limitation. As Hirose evaluated, the snake is only able to propel forward when it assumes the serpenoid curve. Unlike a simple sinusoidal curve, the curvature of this curve changes sinusoidally over its length. Thus if the snake is to travel along a certain axis, then it must displace its body both above and below this axis to form the curve. The problem arises here, if the minimum perpendicular displacement is not maintained, the snake will not move forward. Even with the increase of links, the minimum perpendicular displacement will be much greater than the width of the body.