

## AUTONOMOUS BIOMIMETIC ROBOT BASED MULTI-AGENT SYSTEM FOR DISASTER MANAGEMENT AND RESCUE

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### Abstract:

*This paper discusses the scope and feasibility of autonomous biomimetic robot based multi-agent systems for disaster management and rescue. Search and rescue operations in disastrous situations like earthquake, landslide, fire hazards, mineshaft breakdown etc. are still handled manually. Manual operations in these cases often fail due to complicated nature of the catastrophe. Especially in the case of human entrapment in areas inaccessible to either human or traditional rescue equipment. As such rescue operation suffers from improper strategy and even leads to unintentional further destruction due to lack of proper information along the rescue site. It is clear, proper information in and around the disaster can help successful handling of the catastrophe. Thus information like location of the survivor, state of the obstructions around him/her, state of injury, level of oxygen and hazardous gases are of crucial importance. To gather such widespread information from such difficult terrain, autonomous robots equipped with multiple sensors and capable to move inside difficult to access areas is a good choice.*

*Autonomous biomimetic robot like Snake robot is meant to mimic motion of a natural snake, which does not possess any limb. Natural snakes can undergo wide range of motion and are able to move over rough terrains without the danger of entanglement. Slender structure of the snake body helps a snake to go inside narrow holes. Thus a snake robot able to mimic these features of a natural snake will be of extreme use in handling search and rescue operations. Snake robots equipped with multiple sensors and controlled under multiagent collaborative protocol are expected to bring about acceptable solution to disaster management and rescue. The other such biomimetic robots that can be considered in the autonomous robot team are flapping wing flyers and robot Monkeys. A team consisting of such robots will help in collecting information, distributing food and medicine in disastrous location.*

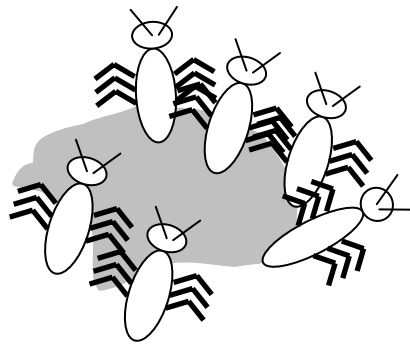
**Key words:** *Autonomous, Biomimetic Robot, Multiagent system, Disaster, Rescue, Snake Robot*

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### Introduction

Disaster management includes both post-catastrophe rehabilitation and rescue operation immediately after the catastrophe. Entrapment of humans inside buildings and under the debris is common in almost all kinds of disaster. In the case of rescue operation from such entrapment fast and effective measures are crucial in saving human lives. The common rescue practice so far is to dig out the whole savaged area without precisely knowing the location of the entrapped people. Such blind operations are time consuming and some times instead of saving lives take away lives. On the other hand some of the catastrophes are inaccessible, as for example breakdown inside mineshafts or inside the subways. In these kinds of catastrophes, rescuers require few days to reach to the victims, where the victims might not survive after long-time starvation or injuries. Sniffer dogs are sometimes used to detect humans inside the wreckage. However, dogs can not give any indication of the state of the victim like state of injury, level of oxygen and other harmful gases around the victim etc. As such priority can not be set in designing the rescue operation.

It is evident from the above discussion that information mapping will play a vital role in designing and executing successful rescue operation. To undertake information mapping inside the entrapments scientist have taken small limbless autonomous robots into their consideration [1-4]. The main advantage of limbless robots over the legged robots is their ability to move in difficult terrains without entanglement. Limbless robots are being assumed to mimic the natural snakes, are made slender so that narrow passages leading to entrapments can be used efficiently to gather information. Natural biological creatures use muscles for their motion. Natural muscles are so powerful that small size muscles can generate lot of power and help keep the size of the biological creatures small. Today's technology has achieved little advancement in the development of artificial muscles [5,6]. Once technology supersedes the natural muscles, biomimetic robots powered with artificial muscles will be able to replace many of the current equipment used in rescue operation. In that case instead of using giant excavators or bulldozers swarm of small robots with collaborative behavior can be thought to handle rescue operations like the collaborative efforts found in natural ants as shown in Fig.1. These robots if featured with communication systems will be able to behave like the natural bees in terms of information exchange.

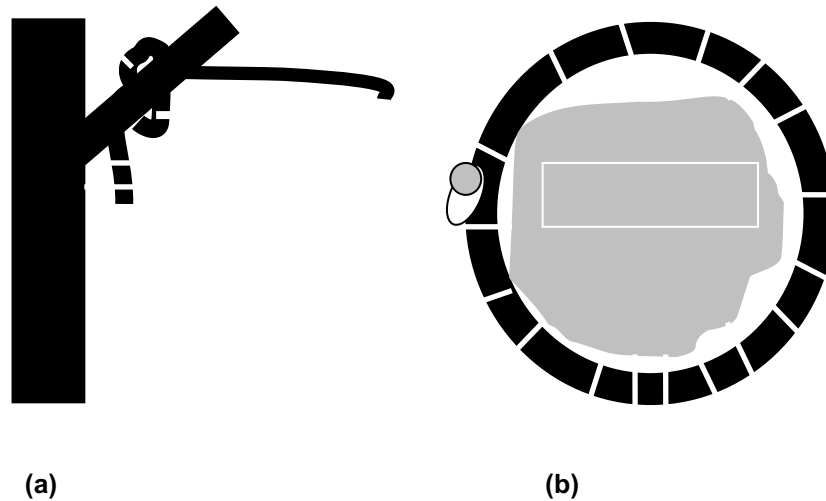


**Fig.1** Collaborative activity in ants

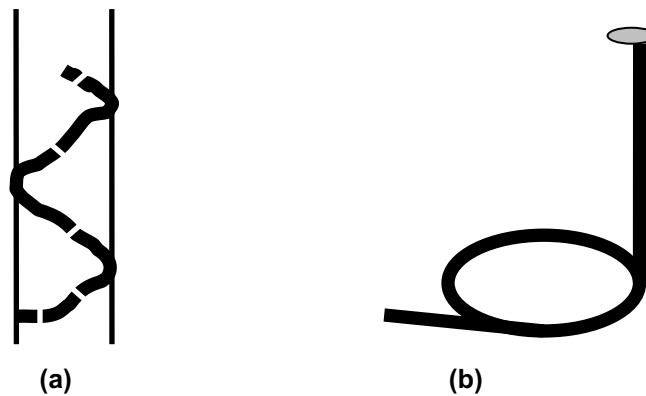
Multiple autonomous robots collaborating and communicating with each other to perform tasks are complex in nature and only achievable provided sufficient intelligence is built in, and a way of communication between them is established. In these approaches increasing robot autonomy allows robots to be delegated certain tasks for longer periods of time making it possible for a single operator to control more robots. We envision future disaster response to be performed with a mixture of humans performing high level decision-making, intelligent agents coordinating the response and humans and robots performing key physical tasks. These heterogeneous teams of robots and people will provide the safest and most effective means for quickly responding to a disaster.

### **Biomimetic Snake Robot**

Snakes are mostly considered as terrifying and life threatening creature for human being albeit snake venom has some medicinal values. Unlike the other creatures snake has versatile motion capabilities. Snakes can reach almost any difficult nooks and crannies due to its slender shape and flexible body. They can also overcome versatile obstacles around its surroundings. Climbing poles or trees and swinging from overhangs are some additional features (Fig.2). Even snakes can climb inside vertical pipes as shown Fig.3.



**Fig.2** Various configuration of snake: (a) propped on a support and extending to reach nearby space (b) wrapping an object

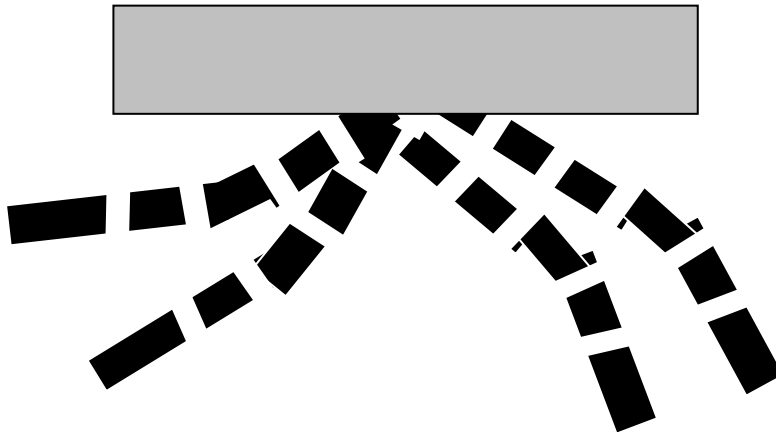


**Fig.3** (a) Snake climbing inside pipes (b) Snake keeps the head upright

Snakes can lock its different segments along the body and become stiff, can keep its head erected in the space. The later feature can be utilized in pushing objects as well as capturing images surrounding the snake.

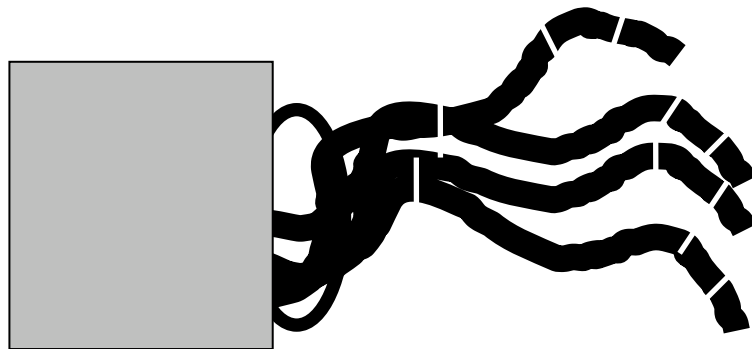
### Snake Robot as Agent

Multi-agent collaboration is natural in humans as well as in some other biological creatures. Multi-agent collaborative activity has got lots of advantages over single agent activity. In the case of multi-agent collaboration among robots redundancy, distributed sensing and actuation play vital role in achieving goals successfully and efficiently. Due to the redundancy in the system, multi-agent system is fault tolerant as well as robust. In a multi agent system different types of robots may be employed for executing different tasks. However, considering snakes as the building blocks like the cells in biological systems different types of actuating systems or robots can be developed on the cite instead of using different specialized robots. An idea of using the snake agents as legs of a single walking robot is depicted in Fig.4.



**Fig.4** Four snakes collaborating as legs of quadruped robot

In Fig.5 parallel efforts of snakes in pulling a heavy load is shown. Handling of heavy loads from under the debris is very critical in rescue operation. Distributed actuation through swarms of snakes believed to be a feasible solution in this respect.



**Fig.5** Snakes in parallel action in handling heavy load

### Conclusions

Considering versatile motion capability and flexibility of shape of snake robots, it can be employed in rescue operation under multi-agent collaborative protocol. However, so far only few researches have been done in the design and development of efficient snake robots with versatile motion capabilities. To achieve such technology, efforts are necessary in the design of strong artificial muscles, design of powerful machine intelligence and efficient collaborative protocols.

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