Creating an Efficient Skeleton Structure of Rodent (Cockroach) Type Robots

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Abstract— Rodents such as cockroaches are found without restrictions of land, air and water borders. Skeleton Design of Cockroach type rodent or may I say "COCKBOT" has been proposed in this paper. Concentrating on mechanical design, this paper enhances the beauty of using artificial muscles and frame structure of Periplaneta Americana.
Keywords: Cockroach, Artificial muscles, Rodent, Robot

I. INTRODUCTION

WE are living in the age of information. The one who has access to useful information can built or exploit things with its usage. Gaining information on terrorists' camps and other criminal bases is crucial as well as a tough call for secret service, national intelligence defense agencies. With this in mind the best way to access these bases without intrusion alarms ringing is to develop, design and mimic animals that have access to almost any part of the world or developing an animal of that particular geographical region. Cockroaches are the only animal types or rodents that are found in domestic, drainage, sewer lines, caves or almost in every region of private and public access. Not only this but also they are nocturnal animals thereby operating them at night won't be a risk.

II. HOW TO SELECT THE SPECIES OF COCKROACH?

It is surprising to note that there are approximately 4000 species of cockroach around the world. Selecting one to mimic was a cumbersome task. [1] is a beautiful work for considering the study of various species in a single book providing all the necessary information. After going through a thorough reading of various species it was decided that classifying rodents is difficult so a selection was made giving importance to various features.

The term oviparous and ovoviviparous can make a great difference in the design of structure. Oviparous indicating that the egg case is held outside the body whereas Ovoviviparous indicating that egg case is held inside the body.

Table1 presents four species of both oviparous and ovoviviparous types. Let's have a look at following species

Scientific Name	Morphological Characteristics		Body Length (mm)		Habitat
			Male	Female	
Periplaneta Americana	Reddish Brown, wings	Full	36-44	29-37	Caves, outdoors, Domiciliary oviparous
Blattaorientalis	Black to very dark brown, Females wingless, males reduced wings		17-29	20-27	Domiciliary oviparous
Periplaneta Australasia	Reddish Brown, yellowish wing margins, Dark pronotum surrounded by yellow edges		36-44	29-37	Outdoors, sometimes Domiciliary oviparous
Nauphoeta Cinerea	Ash colored with blotchy pattern on pronotum; wings shorter than abdomen		25-29		Outdoors, sometimes domiciliary ovoviviparous

Table 1: Species of Various Cockroach Types

After considering the table and data taken into account for geographic distribution the species selection is based on the following priority order habitat, developed state and maximum length.

A. *Selected specie specifications:*

Classification: arthropoda
Class: Insecta
Order: Orthoptera
Genus: Periplaneta

B. *Periplaneta Americana:*

Both sexes have fully developed wings and males occasionally fly or Glide, reddish brown, large body, yellow blotch on pronotum [1].

A few images comprising of various views are shown in figure 1 to figure 5 for identification purposes [4].

Fig. 1: Dorsal view

Fig. 2: Lateral view

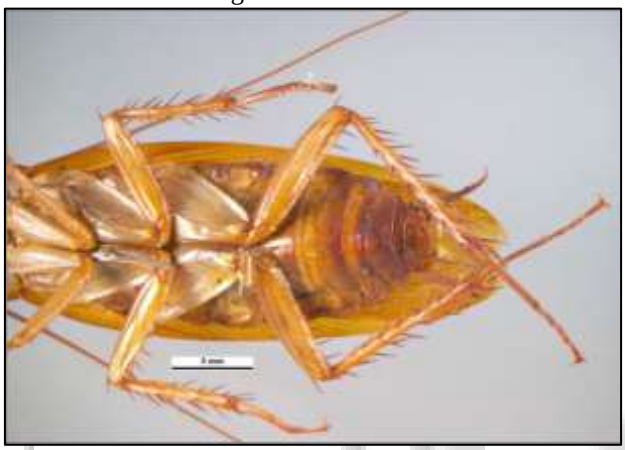

Fig. 3: Legs

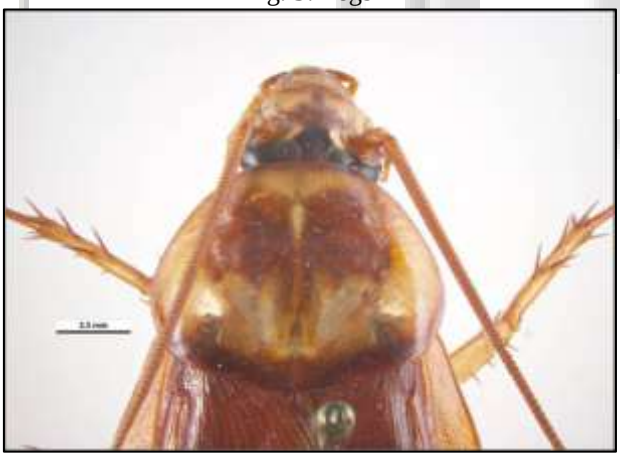

Fig. 4: Pronotum

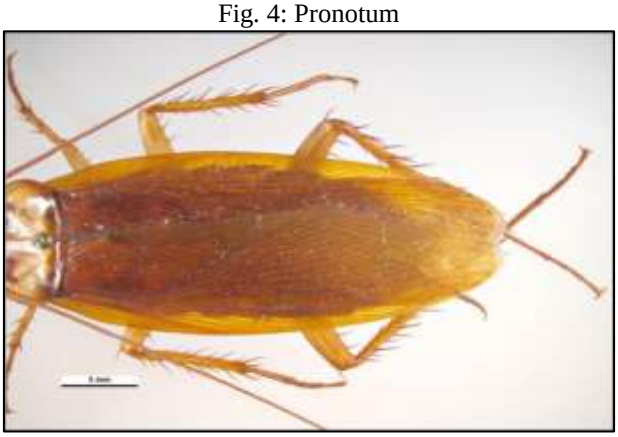

Fig. 5: Wings

III. PROPOSED DESIGN

The proposed Design concentrates on the internal structure and material science for artificial muscles and conduction mechanism in rodent. The outer structure is concerned only in material and the structural design is not proposed. The design consists of simple mimic of cockroach.

A. Features of design:

1) Light weight
2) Instant response mechanism
3) Fast movement in terms of body length

1) Light Weight

The structure of the rodent has a PVDF piezoelectric film spread over an elliptical section through which the legs protrude in the outward direction, thereby distributing weight evenly from center throughout the body and providing a balance to the structure.

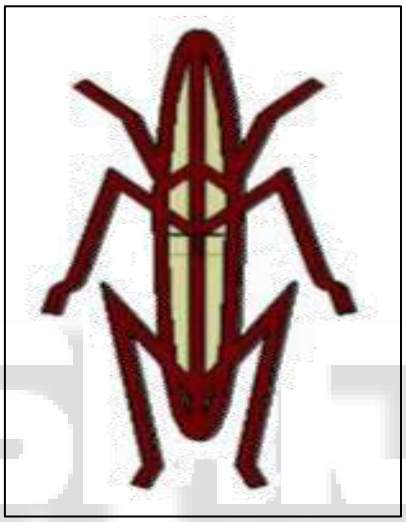

Fig. 6: Light weight Design

2) Instant Response mechanism

The instant response mechanism is made with the help of SMA (Shape memory alloy) type material and a microcontroller.

Shape memory alloy materials have the property of expanding and contracting on application of heat or removal of heat respectively. Many design have been proposed using SMAs but to get accurate and balanced movement is still an ambiguous situation. Here in this design the movement is made possible by the mechanism which may be called Node heating and cooling.

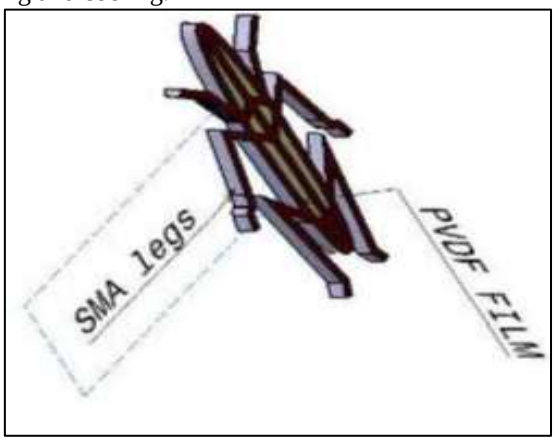

Fig. 7: PVDF piezoelectric film and SMA legs

a) Node Heating and cooling mechanism

Node heating and cooling mechanism promotes timer controlled (microcontroller based) heating and cooling of SMA legs joined through PVDF film at certain NODAL points such as joints where the protrusion of leg starts, curves near knee joint etc.

PVDF piezoelectric film was selected in ellipse shape as cockroaches are invertebrates and as it generates electricity which can be used further in self-destructing mechanism.

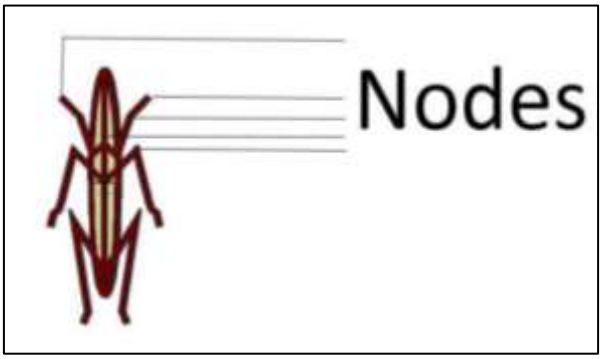

Fig. 8: Few Nodal Points

b) Self-destructing mechanism

The self-destruction mechanism is made with the help of PVDF film connected to a capacitor storing charge for every movement of the cockboat. In case it has to self-destruct, it firsts short circuit the entire circuitry and then a suitable amount of hydro fluoride acid is released to remove the electronics thereby giving no information out.

c) Fast movement in terms of body length

Triggering trough microcontrollers at certain nodes increases the movement speed of the cockboat in terms of body lengths per second. Not only has this but also syncing leg movements provided stability to the structure.

d) Power source and control

It is crucial for cockbot to have a power source still a lifetime of 40hrs can be achieved by alkaline batteries. A microcontroller is used to control the movement, heating and cooling of SMA legs by controlled loop timings for smooth and efficient motion.

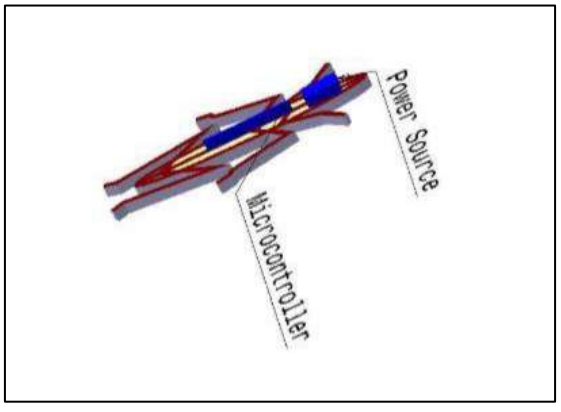

Fig. 9: power source and microcontroller

e) Outer structure

The outer structure can be 3D printed in the shape of a cockroach.

f) Dimensional body constraints

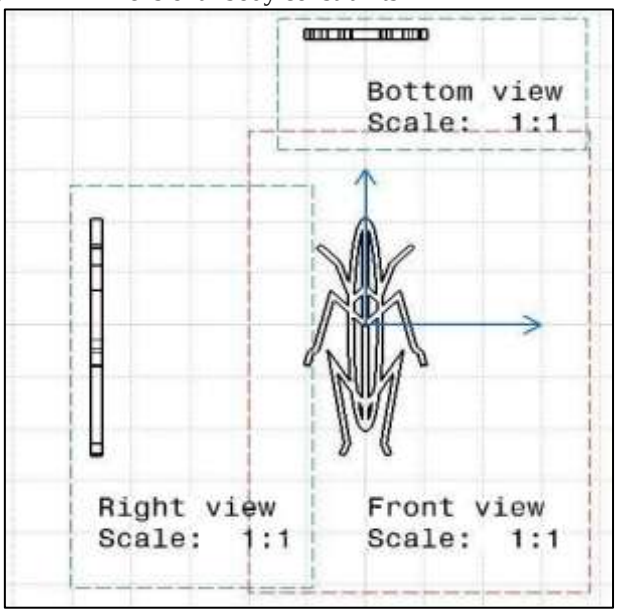

Fig. 10: views of structure

The dimensional views have been made by keeping in the maximum average length of 40mm.This sketch is 5mm wide and distance between legs is 5mm.

IV. Further Improvisation in Design

A. Communication enhancement

To equip communication, the wings in cockbot can have transmitter and receiver in shapes of vessels and the antenna can be used for ad hoc communication.

The electronic circuitry in the structure can be varied according to the usage of an individual. MEMS systems provide a great advantage in using these kinds structure for information access features and spying.

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