A Hexapod Robot Modeled on the stick insect, *Carausius Morosus*

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Agenda

- Abstract
- Introduction
- Mechanical Design
- Leg Controller Design
- Walking System
- Control Infrastructure
- Initial Results
- References

Abstract

- Motivation: Why imitate insects?
  - navigation over uneven terrain
  - adjust gait based on speed
  - overcome or avoid obstacles

- Goals:
  - Imitate the gait of the Stick Insect
  - Add a vision system that creates a depth map which will help the hexapod to avoid obstacles and potholes

(I) Introduction

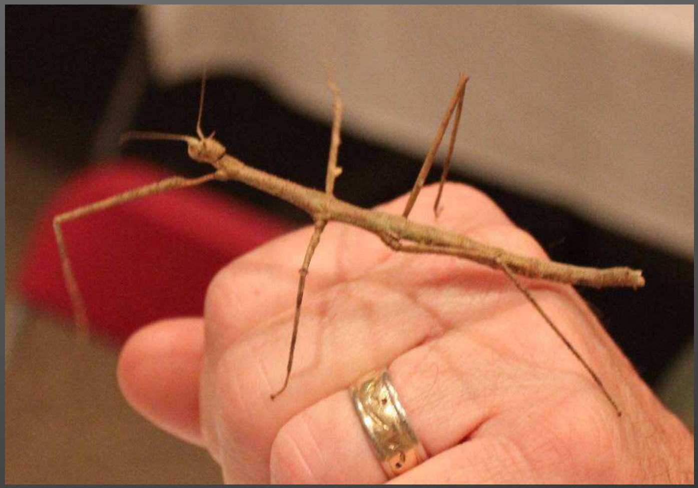
- Previous robots that used insects for inspiration:
  - Tarry Series
  - Robot II
  - LAURON series

- Previously walking sys actions
- New ones based on observation of neurobiological systems controlling the leg movement

BILL-Stick: Biologically Inspired Legged Locomotion Insect

- BILL-Stick

- Carausius Morosus



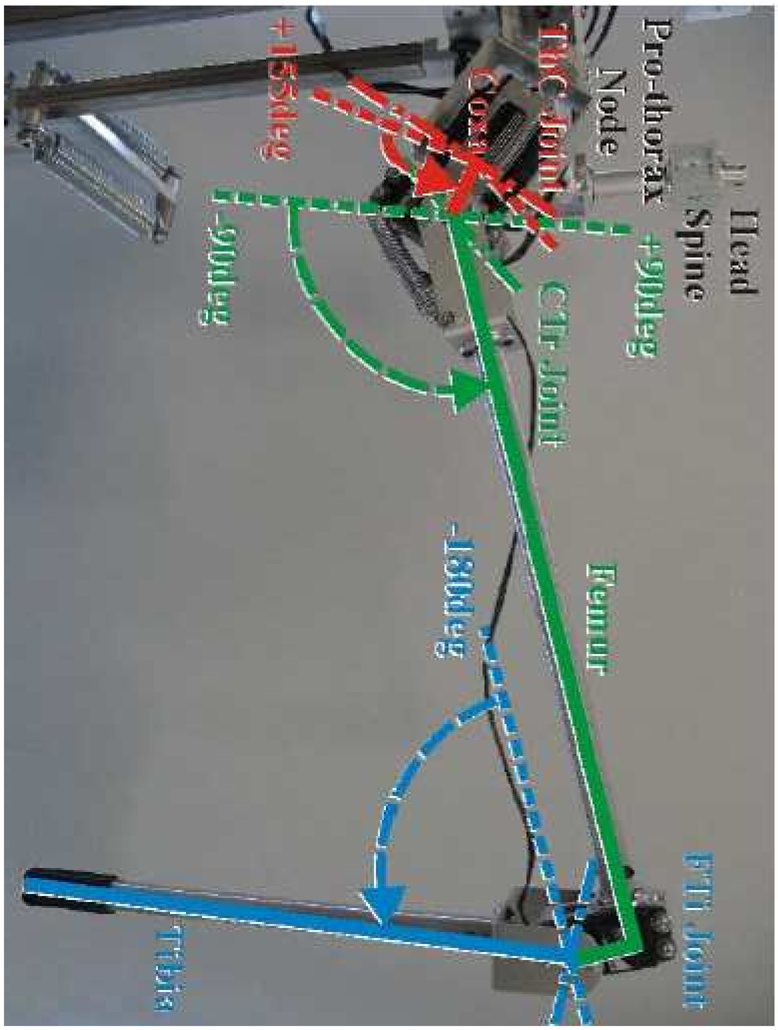
BILL-Stick

- 18.8:1 Scale model of the Stick insect
- Single leg control system based on insect's neurobiological system
- Gait generation based on externally observed stepping patterns

(II) Mechanical Design

Physical Aspects

- Dimensions based on data collected by Cruse and Pfiffer *et al*
- Body and leg segment length-scaled to create hexapod
- Joint attachment angles and joint ranges of motion- used as they were


Head
Spine
Pro-thorax
Node
ThC Joint
Coxa
+155deg
+90deg
-90deg
CTr Joint
Femur
-180deg
FTi Joint
Tibia

Joint Actuators

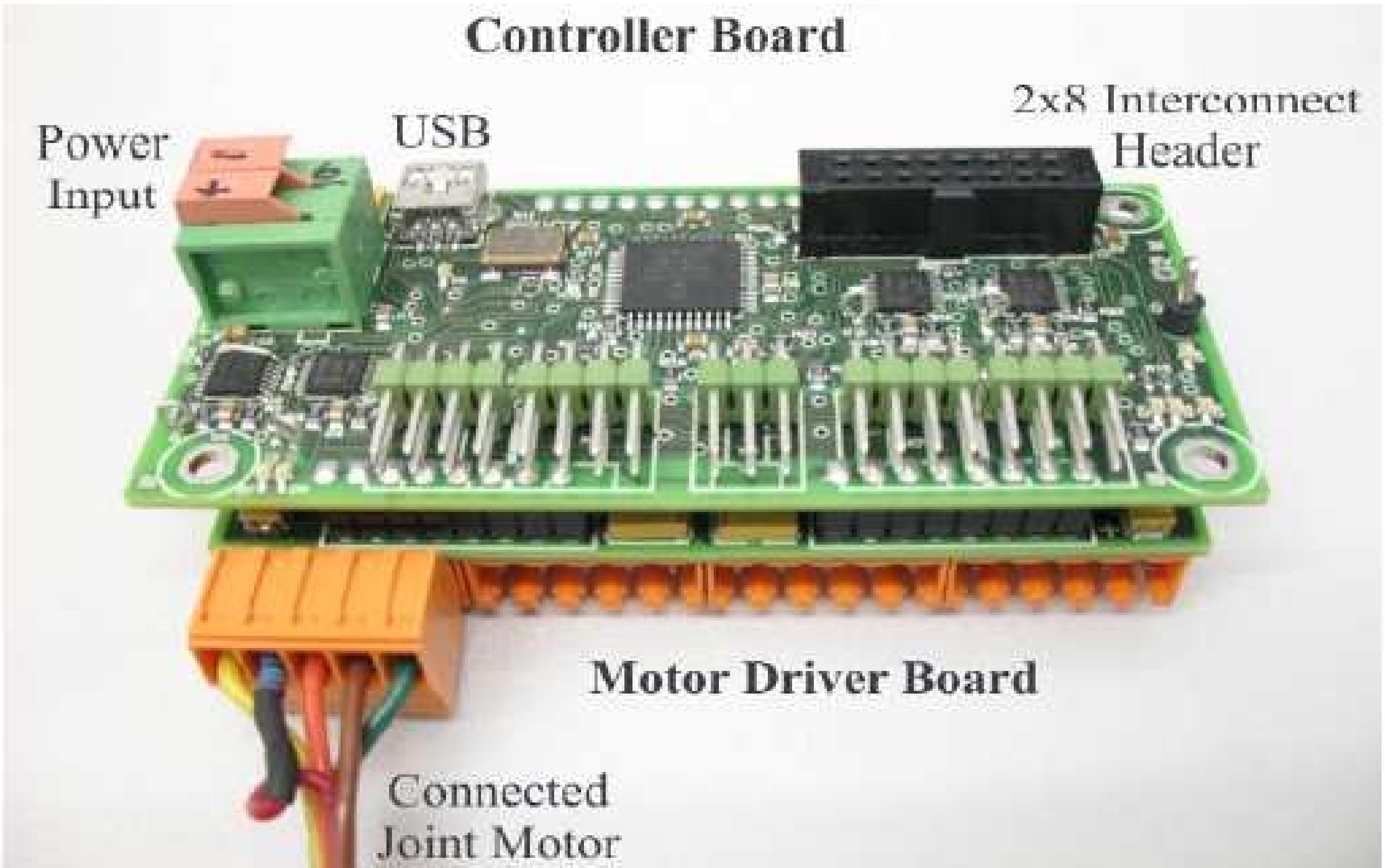
- Leg joints actuated by modified hobby sevro motors, the Hitec HSR 5990TG
- these motors chosen for:
  - High torque
  - Titanium geared transmission
  - Can be powered through 2-cell Li-Ion batteries

- Leg controls system needs to know the current joint angles(servo position) and joint load(current consumption).
- So, the hobby servo motor is modified
- The motor is disconnected from its drivers and connected to the Motor Driver Boards and Controller Board

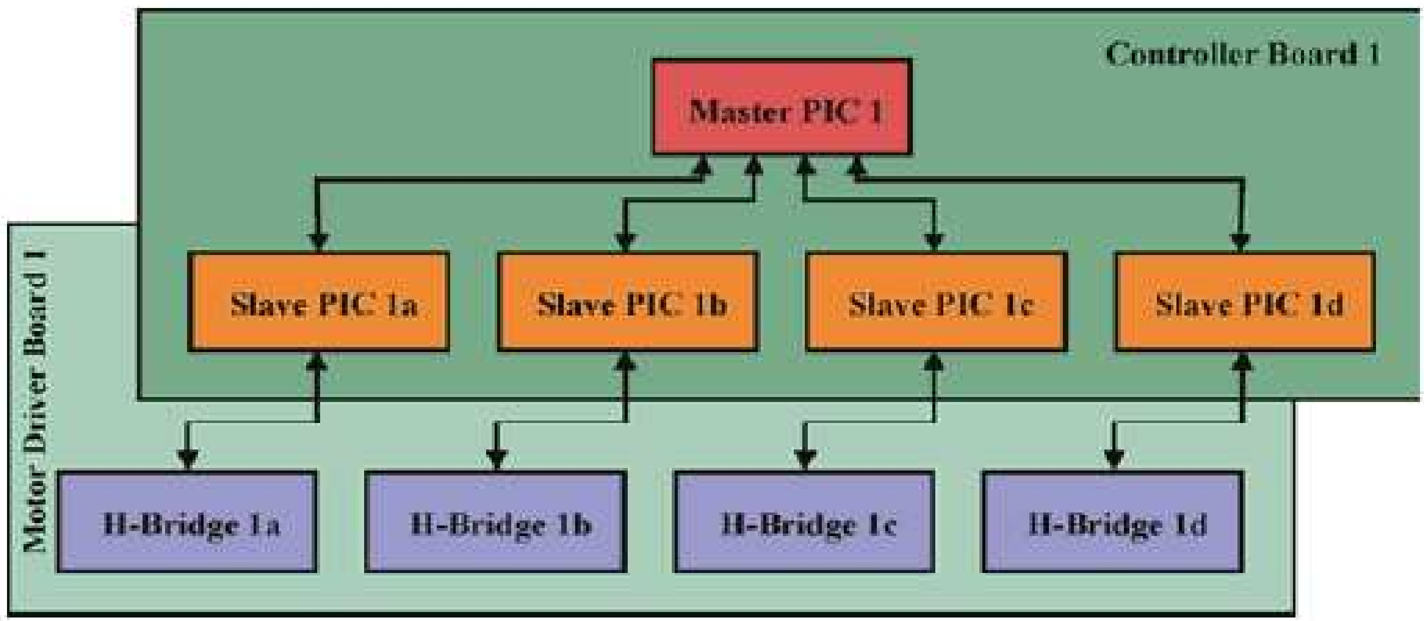
(III) Leg Controller Design

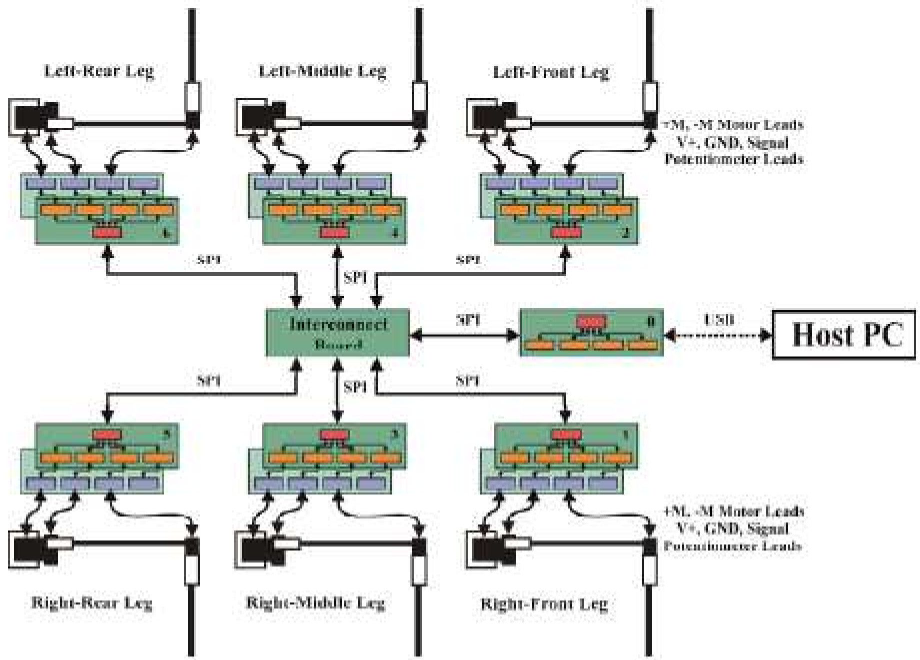
- The leg controller design consists of 4 parts:
  - Controller Board
  - Motor Driver Board
  - Router
  - Interconnect Board

- (A) Controller board
- Custom made leg with
  - high control loop speed
  - capability of interfacing with a variety of motors and sensors
- Each leg has its own controller.
- All the leg controllers are interconnected for data sharing for gait generation


Controller Board
Power Input
USB
2x8 Interconnect Header
Motor Driver Board
Connected Joint Motor

- Contains:
  - One PIC18F4550 microcontroller
  - Four PIC16F616 microcontrollers





Left-Rear Leg
Left-Middle Leg
Left-Front Leg
+M, -M Motor Leads
V+, GND, Signal
Potentiometer Leads
6
4
2
SPI
SPI
SPI
Interconnect
Board
SPI
0
USB
Host PC
SPI
SPI
SPI
5
3
1
+M, -M Motor Leads
V+, GND, Signal
Potentiometer Leads
Right-Rear Leg
Right-Middle Leg
Right-Front Leg

(B) Motor Driver Board

- A motor driver board is attached to each controller board
- Contains: Four H-Bridge Circuits(one for each motor channel)

- (C) Router Board
- No physical difference between Controller and Router
- Router board uses USB to communicate with a central computer

- (D) Interconnect Board
- Used to couple custom buses between 6 controller boards and router

(IV) The Walking System

- It consists of:
  - Central computer to provide walking parameters
  - Leg controllers to execute leg control
  - Gail generation algorithms

Leg control

- Pattern generation : nominal stepping motion
- Reactive system :Alters nominal motions according to environment
- Reflexes:
  - searching Reflex
  - Elevator Reflex

Gait control

- Observations of insects have yielded a set of rules to create coordinated gait patterns

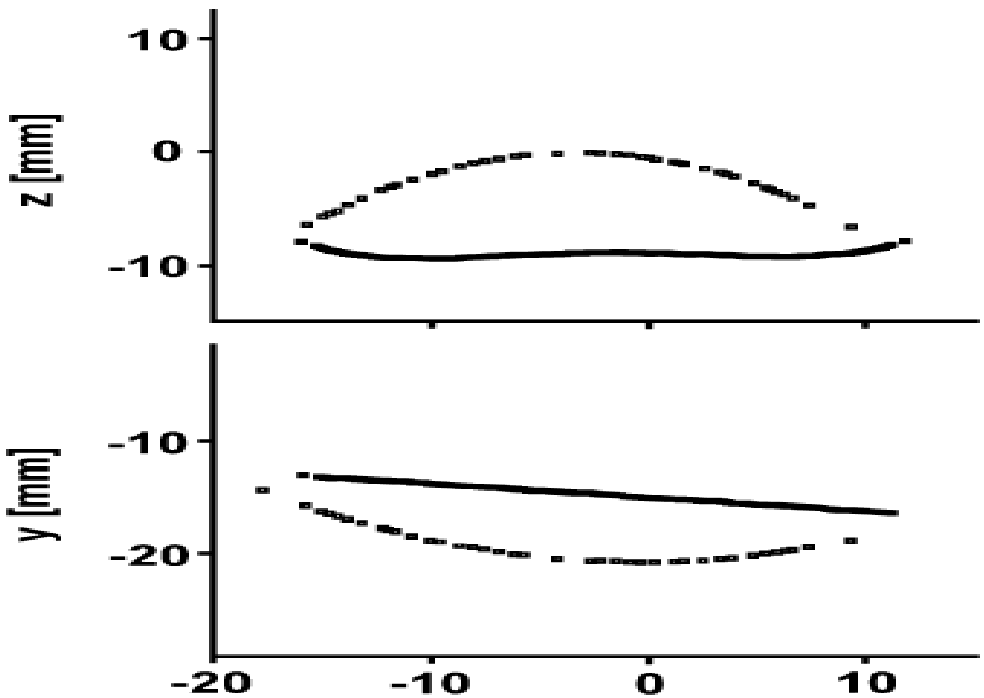
- The signals from ThC joint angles are used to influence the stepping patterns of neighboring legs

(V) Control Infrastructure

- Two central computers : fit-PC2 (CompuLab, Haifa, Israel) with a 1.6GHz Intel Atom Z530 processor, 1GB of RAM, and a 160GB HDD and OS Ubuntu 10.10
- Central Computer #1 : database and 3-D physics engine simulator
- Central Computer #2 : Depth maps using stereo vision

Initial Stepping Result

- First tested for single leg of hexapod
- The right middle leg was tested and gave the following results



Conclusion

- Implemented leg control methods as identified in the insect neurobiology
- Implemented gait generation methods based on insect observations
- combine these with a learning system that is capable of identifying and predicting reflex-triggering events.

References

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- http://en.wikipedia.org/wiki/Carausius_morosus
- http://www.micromo.com/application-case-study-lauron-nature-inspired-robot.aspx