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Design and Simulation of Tetrahedral Robotics

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Design and Simulation of Tetrahedral Robots

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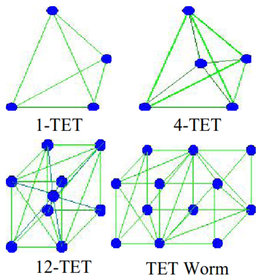
Concept Overview

The basis for this type of robot is the simplest three dimensional geometry, the tetrahedron. Multiple tetrahedra can be combined to produce more complex arrangements which could ultimately form a type of robot with a unique method of movement that does not currently exist. A tetrahedral robot moves by expanding and contracting parts of its tetrahedral structure in choreographed ways. The robot is capable of a varying number of gaits depending on its structural complexity. This type of robot could have many advantages over other wheel-based designs which include:

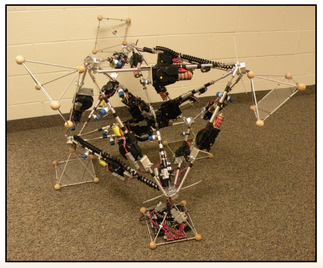
- The capability to traverse difficult terrain such as sand, loose gravel, ice, and rocky environments.
- The ability to be reconfigured and repaired in place as required.
- The ability to combine with other robots to built much more complex structures such as the “worm” shown below.

To the right are several tetrahedral-based robots where the numbers are descriptive of how many tetrahedral cells each is composed of. The 1-TET and 4-TET are the simplest whereas the 12-TET and the worm are much more complex.



Previously at Hope

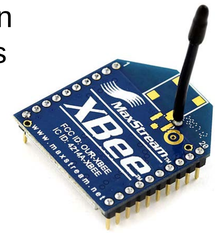
In previous years, students have worked through multiple stages of TET robot development. This included gait simulation and prototype development. The most recent project was the modeling, design, and construction of an 8-TET prototype. This was undertaken to build upon the previous 4-TET model. The 8-TET used motorized car antennas for its struts and had pyramid shaped feet. The onboard Innovation First robot control unit communicated wirelessly with a computer GUI. The 8-TET prototype taken as a whole was successful, but some aspects of its operation needed improvement.



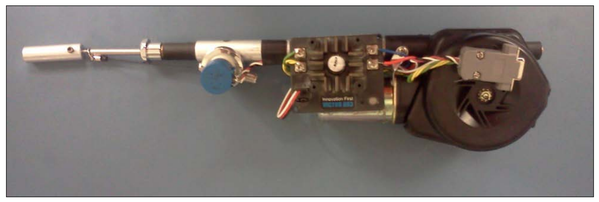
- Communication was very slow due to hardware limitations.
- The inter-strut wiring was messy and added extra complication to the robot.
- Each strut was not an independent unit.

New Robot Control System

Wireless Communication Between XBee Modules

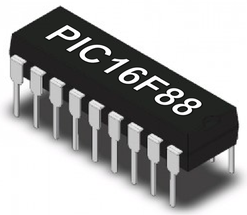


Serial Communication

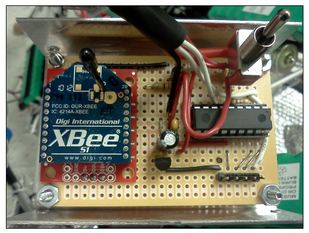


Potentiometer Reading

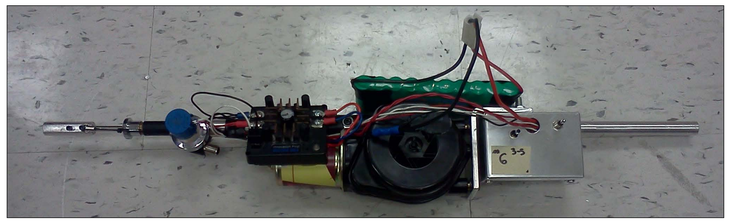
PWM for Motor



Final Implementation of New Control System



The electronic hardware present on each strut

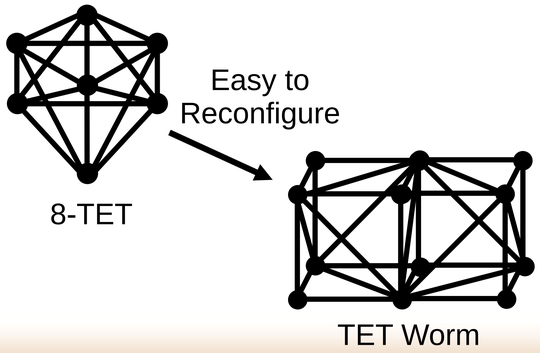


The fully assembled tetrahedral robot strut

Advantages of New Control System

The main reason for designing and implementing the new control system was so that each strut would be independent. The old control system had to be wired to a central control unit which was messy and prevented reconfiguration of the robot’s shape. With the new system, struts can be interchanged without any rewiring. Because a main goal for these types of robots is reconfiguration, this new feature is moving tetrahedral robotics one step closer to the ultimate goal.

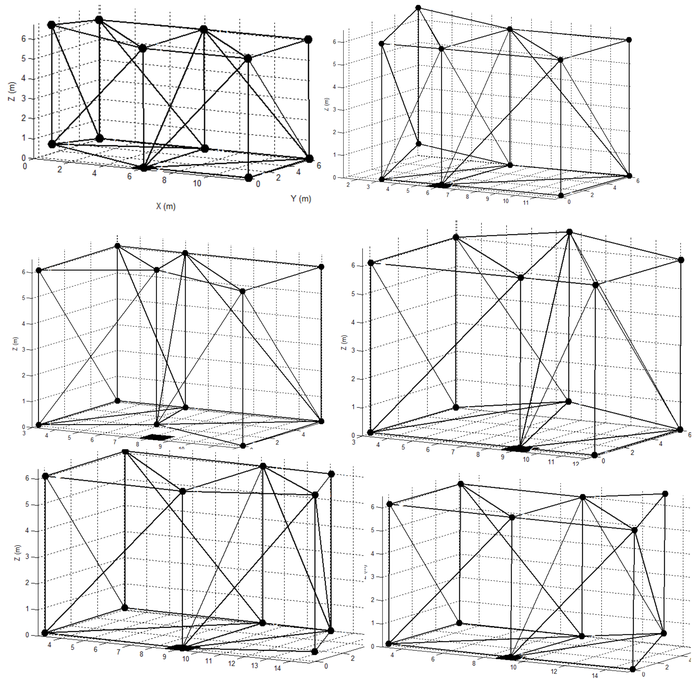
Another advantage of the new control system is that it is much faster than the old system. The old system used a single wireless transceiver and control unit which led to a bottleneck in transmission speed. With 18 separate transceivers and microcontrollers, this bottleneck is removed and the transmissions needed to control the robot are faster.



Gait Design for New TET Configuration

Up to date, the TET robots that have been built at Hope have all moved by tumbling or rolling. These gaits work, but they result in the orientation of the robot constantly changing. One possible way to avoid this is to design a TET robot that moves by crawling. A TET design that could accommodate a crawling gait is the TET worm.

The best Gait is shown below:



This crawling movement is what was to be tested. If implemented it would replace the tumbling motion which an advantage for climbing tough terrain and keeping its orientation. The TET Worm model was created and may be built in the near future.

Acknowledgements

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