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Stiquito II and Tensipede: Two Easy–to-Build Nitinol–Propelled Robots

by

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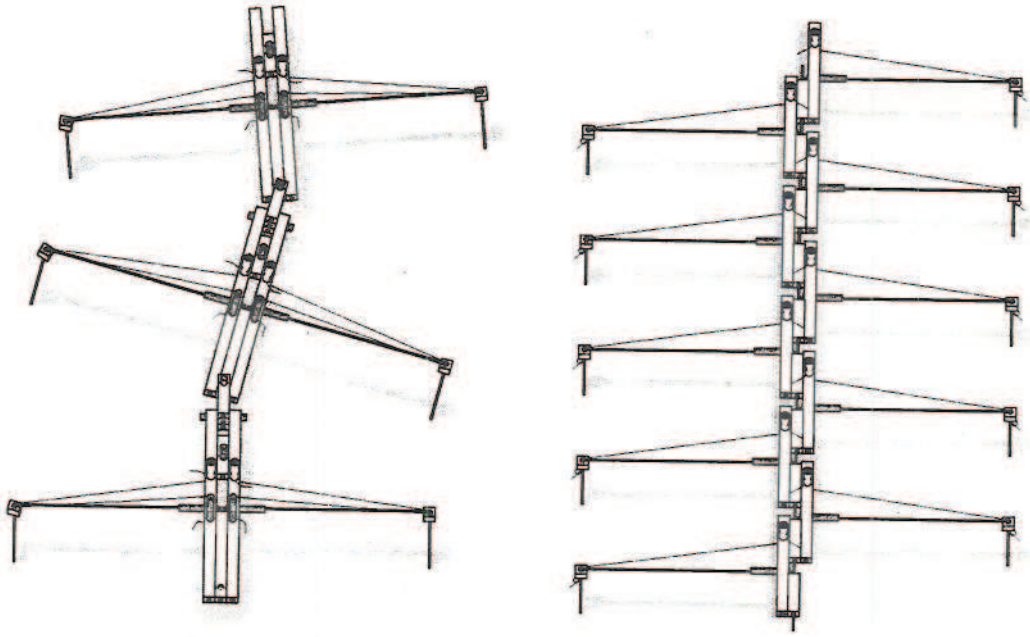

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Abstract

Stiquito II is an improved Stiquito: it is larger, modular, has an articulated body, two-degree-of-freedom legs, and carries more weight. Tensipede is a simple, modular robot centipede. Stiquito II and Tensipede are easier to build than Stiquito. Both are larger and easier to handle. The assembly sequences are simpler, and require only common, sturdy tools. A mistake typically affects only one module instead of the entire robot.

This technical report contains five major sections: a tutorial that introduces necessary skills as the reader builds a practice leg; the instructions to build Tensipede; the instructions to build Stiquito II; the instructions to build an interface to the parallel printer port on IBM PCs and compatible computers; and a programmer's guide with BASIC programs that demonstrate how to control each robot.

RIGHTS AND PERMISSIONS

This technical report is not copyrighted. You may make as many copies as you wish for non-commercial use. You may build as many Stiquito IIs and Tensipedes as you want for research or education. Indiana University reserves all rights to commercial sale or use of Stiquito II and Tensipede.

"Stiquito®", "Stiquito II™", "Sticky™" and "Tensipede™" are trademarks of Indiana University.

0. BUILDING STIQUITO II AND TENSIPEDE IS AS EASY AS 1-2-3

1. **Skim through the technical report** to familiarize yourself with its contents.
2. **Build the practice leg** to develop the skills you need to build either robot.
3. **Follow the instructions** to build either Stiquito II or Tensipede.

1. INTRODUCTION

Look for this helping hand. It will point to a hint to build a better robot.

1.1 A BRIEF HISTORY OF STIQUITO

Legged robots are typically large, complex, and expensive. These factors limited their use in research and education. Few universities could afford to construct robot centipedes, or 100 six-legged robots to study emergent cooperative behavior; even fewer could give each student in a robotics class his or her own walking robot.

The introduction of Stiquito in 1992 changed that. Stiquito was developed from a larger and more complex robot called "Sticky" because it looked like an insect commonly called a "walking stick." Sticky was very difficult to assemble and rather fragile, so a simpler design was sought. During this process multiple components were combined into single, robust, mechanical devices. The best example is Stiquito's leg, which carries the weight of the robot, acts as a leaf spring to provide bias force for the nitinol, and delivers the current that powers the nitinol actuator. A series of five small robots were eventually built that culminated in Stiquito.

Stiquito is a small, simple, and inexpensive six-legged robot that has been used as a research platform to study computational sensors, subsumption architectures, neural gait controllers, emergent behavior, and machine vision. Stiquito has also been used to teach science in primary, secondary, and high school curricula. As of 1994 more than 2500 Stiquitos have been distributed. However useful it has been during the past two years, hundreds of users have taken the time to point out the major flaws in the original design:

- it is hard to build, especially for young people or those not mechanically inclined,
- it requires costly, hard-to-find, or easy-to-break tools to assemble, and
- it cannot be easily adjusted to operate reliably.

These problems have been resolved, as far as is possible, in Stiquito II and Tensipede. These robots were developed to provide larger and more robust platforms for research at Indiana

University's Analog VLSI and Robotics Laboratory, and yet be easy enough to build that they could be used educationally. Even though both robots are made from simple modules, if you have never built models, assembled electronic circuits, or used hand tools to cut plastic, bend wire or drill small holes, I urge you to build the practice leg before attempting to build your robot. Care and patience are still needed to assemble a Stiquito II or a Tensipede, but it is easier than building the original Stiquito.

Educational use of Stiquitos depends on their low cost, so a great deal of attention was given to making the improved design inexpensive. As a result, the Stiquito II kit is the same price as the original kit and technical report. The Stiquito II kit with the parallel port interface parts and this technical report costs as much as two of the original Stiquito kits. The cost reduction is possible because less labor is required to pack the kit, and the manual controller, hook-up wires, and 9-volt battery connector have been eliminated.

1.2 A BRIEF COMMENT ON STIQUITO FROM THE AUTHOR

In nature Stiquito and Stiquito II would be greedy, blind, crippled, retarded ants. They consume electricity voraciously; they have no sensors or effectors (at least as as described in this technical report); their legs lack the numerous degrees of freedom of an ant; their controller, an IBM personal computer, is overwhelmingly large, clunky, and incapable compared to the ganglia that serve an ant (at least to accomplish an ant's tasks).

So why build Stiquitos?

Well, *I* build them because they are simple, they are fun, and they let me investigate robotics without getting a million-dollar grant. I build Stiquitos because I have yet to construct anything the size of an ant that has the capability of an ant. But...I'm working on it.

I encourage all readers of this report to improve on Stiquito, and assure you that if you build a better ant-like robot, I'll be standing in line to get one.

1.3 ABOUT THIS TECHNICAL REPORT

This technical report was written on a Macintosh SE computer with a Radius Accelerator and Radius Two-Page (monochrome) Display. Microsoft Word 4.0D was used for the text and page layout, and Canvas 3.0.6 was used to generate the illustrations. The illustrations are composed of

objects from which a "virtual" robot was assembled. To preserve the accuracy of the figures, many are rendered as bitmaps.

The report is structured to help the beginning robot builder. After conducting numerous Stiquito workshops, and receiving more than 5,000 electronic mail messages about the robot and the first technical report (TR 363a), these steps were taken to improve the presentation:

- Large figures that illustrate the desired appearance of each major component are presented at the beginning of the section that describes how the component is built. This helps the builder understand the steps in the assembly process, and visualize the relationships between the parts and the finished component. The illustration of the component is repeated at reduced size to mark the end of the assembly. This helps partition the assembly process into related groups of steps.

- *Cues* — small pictures — are used to focus the builder's attention during each step of the assembly. Cues warn the builder in advance of common mistakes, point out critical steps in the assembly, identify which parts must be made precisely, or indicate when the assembly can tolerate a little sloppiness. Cues are my attempt to share my robot-building experience with the reader.

- The names of the parts have been chosen to emphasize the modularity of the design. While there is no need for complex part numberings — after all, Stiquito II is not a space shuttle — there is still a need to avoid cumbersome and lengthy descriptions of a specific (and usually very small!) part. All parts are made during the first steps in the assembly process. This seems to reduce stress among first-time builders by literally breaking the apparently-complicated assembly sequence into simple, tangible parts.

If you, the reader, encounter mistakes in this report, find a better way to assemble the robot, or develop an improved or new and innovative nitinol-actuated robot, I encourage you to either post your results to the stiquito newsgroup, **stiquito@xcf.berkeley.edu**, or send me electronic mail at **stiquito@cs.indiana.edu** or jwmills@cs.indiana.edu. The first two addresses listed are those that will receive reasonably prompt replies.

If you have a question, and have read the relevant parts of this report, post your question to the mailing list. There are many people who have successfully built Stiquitos out there, and they are typically friendly and willing to help you. So am I, but the volume of e-mail directed to me means that you risk having your messages go unanswered. Please post to the list!