ArachnoBotics
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March 22, 2010

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 440 Capstone Project: *Progress Report: ArachnoBot™ Project*

Dear Dr. Rawicz,

Please find attached the document titled *Progress Report: ArachnoBot™ Project*, for our ENSC 440 Capstone Engineering Project.

The enclosed progress report outlines the work completed by the members of ArachnoBotics Research Inc. on each component of the ArachnoBot™ prototype. The project's electrical, mechanical, and software statuses are discussed using specific technical details, and includes appropriate references.

ArachnoBotics Research Inc. consists of five highly motivated, innovative and talented fifth year engineering students experienced in a wide range of technical disciplines: Daniel Naaykens, Pavel Bloch, Pranav Gupta and Stefan Strbac.

If you have any concerns or questions regarding our proposal, please feel free to contact me by phone (778.893.3303) or by email (pranav_gupta@sfu.ca).

Yours sincerely,

Pranav Gupta
Chief Executive Officer
ArachnoBotics Research Inc.

Enclosed: *Progress Report: ArachnoBot™ Project*

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Progress Report: ArachnoBot™ Project

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List of Acronyms

3D - Three Dimension
ADC - Analog to Digital Converter
DC - Direct Current
DOF - Degrees of Freedom
ESA - European Space Agency
FPGA - Field Programmable Gate Array
FSL - Fast Simplex Link
IP - Intellectual Property
PCB - Printed Circuit Board
PID Controller - Proportional-Integral-Derivative Controller
PWM - Pulse Width Modulation

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1. Introduction

ArachnoBotics Research Inc. is currently developing the first prototype of the ArachnoBot™, a fully autonomous robotic hexapod walker, based on a project commissioned by the European Space Agency (ESA). While the original project specifically targets space exploration, ArachnoBotics Research Inc. has furthered the project to design a small, lightweight robot capable of scaling any complex terrain, and subsisting in extreme environments. This project is currently entering the integration stage of all the separate components, and plans for final testing are being developed.

2. Mechanical Hardware Status

The 3D Model of the ArachnoBot™ has been designed to meet the functional, and design specifications [1][2] of our project and has been modeled using the 3D Modeling program SolidWorks [3]. This model is shown below in Figure 1, and demonstrates how each electromechanical component fits together. It is being 3D printed using an InVision® HR Si^2 3D Modeler [4] and VisiJet® SR-200 Plastic Material [5]. There are currently two legs printed, and in use for integration testing.

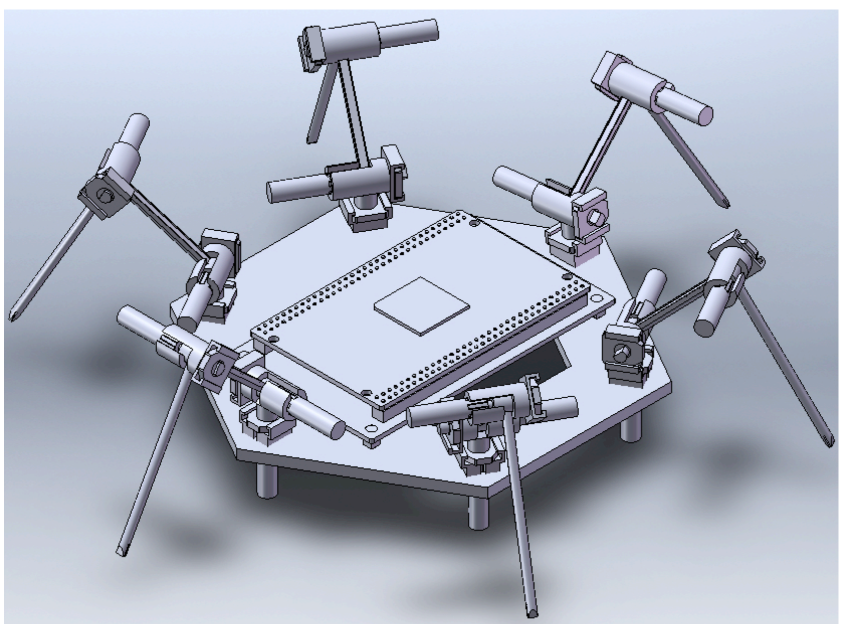

Figure 1: ArachnoBot™ Prototype 3D Model

3. Electronic Hardware Status

The electronics design for the ArachnoBot™ has been through many implementations, all following the main goal of a flexible, cost-effective design with a small form factor. Currently, all parts but the voltage regulator and barrel jack have been selected and incorporated into the electronics schematic. What remains then is the selection of a proper voltage regulator and barrel jack, and the two-layer PCB design using Altium Designer Suite [6]. The anticipated

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date of completion for the PCB design is Sunday, March 28 and the date for the manufactured PCB to arrive is Wednesday, March 31.

4. Software Status

The framework system of the ArachnoBot™ has been designed and synthesized to meet the available resources of the Xilinx Spartan-3A DSP XC3DS 3400A FPGA on the XCM-016 FPGA board acquired to implement the processing module. The framework is designed to use seven MicroBlaze processors [7], with one processor dedicated per leg, and one master controller. This method has simplified the coding process, as each leg is completely identical, only one leg processor needs to be fully coded and tested. Figure 2 below shows how the MicroBlaze processors interface inside the FPGA.

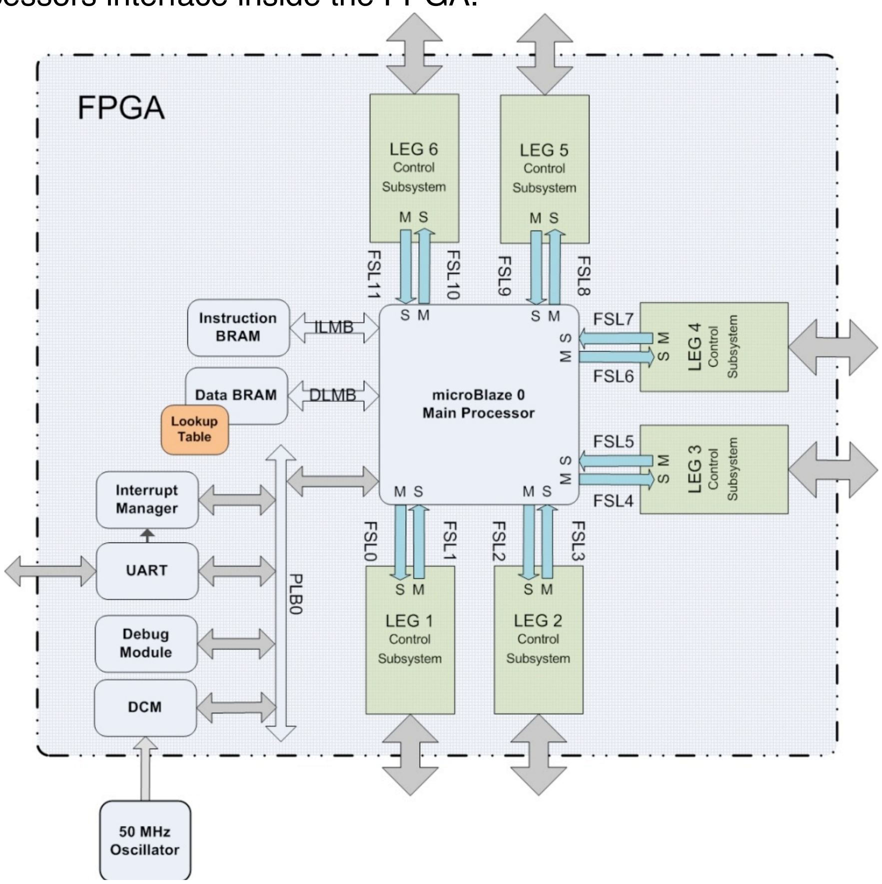

Figure 2: Internal FPGA Controller

The Xilinx XPS Timer/Counter IP has been customized to generate two PWM signals, for forward and reverse movement of the motor. This custom IP ensures only one PWM generating timer will be required per motor, allowing considerably reduced resource usage. Inter processor communication will be via the Xilinx Fast Simplex Link (FSL) bus. Each leg processor has its own dedicated bus to the main processor. Figure 3 shows each leg processor's subsystem.

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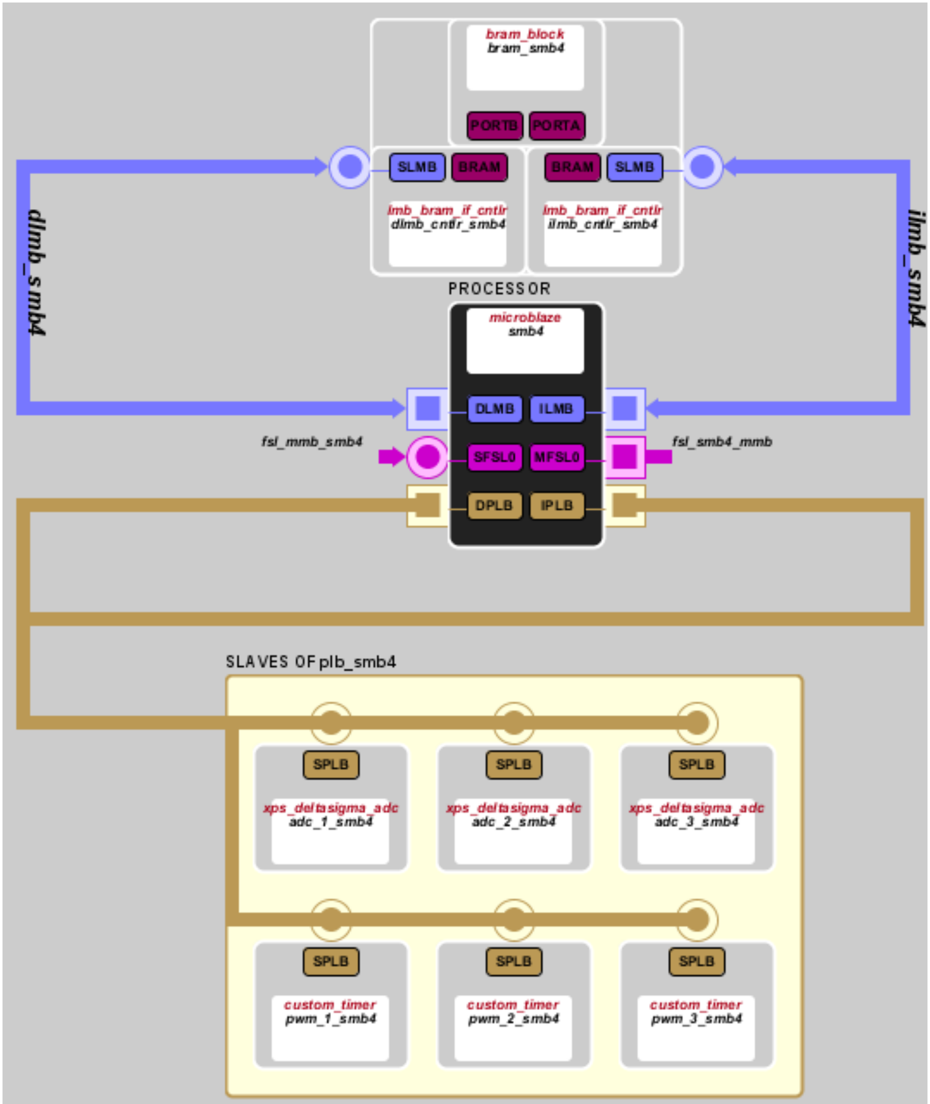

Figure 3: Leg MicroBlaze Processor Sub-System

5. Integration Status

The H-Bridge control circuit for one leg has been created on a breadboard. This circuit is connected to one of the prototyped legs, which has been mounted with both the motors, and the potentiometers needed for the leg control. Control of the leg is currently possible using human control through input switches, and with FPGA control currently being tested. In order to use the FPGA for control, a separate breadboard has been used for the comparator circuit, which interfaces the potentiometers with the FPGA Analog to Digital Converter (ADC).

6. Action Items

The remaining items to be completed before the ArachnoBot™ prototype is completed include: PCB design and fabrication, Walk cycle design and implementation, and completion

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of the FPGA coding. Findings from the integration testing will be used to update the ArachnoBot™ mechanical hardware, which will be re-printed on Wednesday, March 24.

7. Budget Status

Our project is currently coming in under budget. This has been accomplished by testing singular components ordered as samples from the manufacturer, instead of purchasing redundant parts. This allows more room for further unexpected charges, as well as handling the shipping costs.

Table 1: Current Project Budget

Part	Part Number	Quantity	Price
FPGA Development Board	XCM-016 [8]	1	$600.00
Potentiometer	SV01 [9]	20	$30.00
H-Bridge	MPC17550 [10]	6	$40.00
Comparator	MAX9144 [11]	4	$15.00
DC Motor	GH6124S [12]	20	$250.00
PCB Manufacturing			$1000.00
Rapid Prototyping			$100.00
		Proposed:	$2,300.00
		Total:	$2,035.00
		Saved:	$265.00

8. Human Resources

The ArachnoBotics Research Inc. members have moved into a set pattern of working together to complete objectives, with each group member building upon the works of all the others.

9. Conclusion

The ArachnoBot™ project is approximately 60% completed, and is currently in the integration stage. The component selection is finalized and included in the references, with all of the parts on order for the PCB fabrication. The only foreseeable setbacks of the project are based around the PCB fabrication; however, in case of fabrication failure a backup plan using the prototype board of the FPGA development kit has been devised. This route is was devised as a backup plan as the prototype board is both too large, and too heavy for the Functional Specifications. The ArachnoBot™ prototype is scheduled for completion on April 15th, with the remaining time until the project demonstration set aside for trajectory testing and documentation.

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10. References

[1] ArachnoBotics Research Inc., *Functional Specifications of the ArachnoBot™.* Feb 8, 2010

[2] ArachnoBotics Research Inc., *Design Specifications of the ArachnoBot™.* March 11, 2010

[3] *SolidWorks*. Dassault Systèmes SolidWorks Corp
Available: http://www.solidworks.com/

[4] *Products | 3-D Modelers | InVision HR.* 3D Systems
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[5] *Products | 3-D Modelers | VisiJet.* 3D Systems
Available: http://www.3dsystems.com/products/solidimaging/visijet/index.asp

[6] Altium, *Altium Designer Suite*. 2009
Available: www.altium.com

[7] *MicroBlaze Soft Processor Core*. Xilinx
Available: http://www.xilinx.com/tools/microblaze.htm

[8] *XCM-016*, HumanData Ltd.
Available: http://www.hdl.co.jp/en/spc/XCM/xcm-016/index.html

[9] *SV01 Rotary Position Sensors*, Murata Manufacturing Corp.
Available: http://www.murata.com/catalog/r50/el0595.pdf

[10] *MPC17550 Quad H-Bridge*, Freescale Semiconductor
Available: http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MPC17550

[11] *MAX 9144 Comparator*, Maxim
Available: http://www.maxim-ic.com/quick_view2.cfm/qv_pk/3010/t/d

[12] *GH6124S Miniature Planetary Gearhead*, Marswell
Available: http://www.gizmoszone.com/shopping/html/pages/612datasheet.pdf

[All referenced sites accessed on March 22, 2010]

10.1. Photo References