Rhino Glove

Making Things Interact – Final Project

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1 – Introduction

The goal of this project is developing a wireless glove and a software framework to manipulate a parametric model in Rhino 3D. The glove reads user's hand movement and gestures using mounted sensors on it. Then a LilyPad Arduino gathers sensors data as input, processes them, and sends them using a XBee module wirelessly to the computer. The software framework on computer gets sent data using another XBee module, connected to the computer. Finally, the framework translate data to information for controlling the parametric model in Rhino 3D.

2- Description

The Rhino glove is made of an ordinary glove, on which 3 bend sensors, a LilyPad 3 axes accelerometer, a LilyPad Arduino, a LilyPad LiPower, a LilyPad power supply, a rechargeable battery, a LilyPad XBee Shield and a XBee module have been mounted.

The bend sensors have been mounted in the glove fingers. These sensors act as a resistor; their resistance increase when they have been bent. So, when user bends his or her finger change in bend sensor resistance occur. As a result, reading value of bend sensors resistance indicates user's finger figures. Based on finger figures, software framework interprets user's hand movements. In this case, while all fingers are bent, hand movements move the object. While index finger is bent, hand movements extrude object faces. While middle finger is bent, hand movements rotate object. Finally, bending ring finger bake object – make its form unchangeable.

Also, there is a LilyPad 3 axes accelerometer mounted on glove, near the wrist. It works as a sensor that calculates hand movement acceleration in any direction, and, send three values, one for each axis, as an output. These three values will be used, by software framework to calculate hand movements and rotations. So, hand movements and rotations changes parametric model values, based on finger figures.

Next, all of these sensors are connected to a LilyPad Arduino. A 3.5V rechargeable battery, which is connected to the LilyPad through a LilyPad LiPower, supplies power for glove. It could be easily recharged or changed. The uploaded Arduino program on the LilyPad processes input values, and, send an integer to the LilyPad TX port using serial communication. The integer contains all the data required for manipulating the parametric model. The LilyPad TX port is connected to XBee breakout RX port. The

XBee breakout, which has been powered by same power supply as the LilyPad, carries out a XBee module. The XBee module serves as a router, and establishes a wireless connection with another XBee module which has been connected to computer using Maxstream breakout, and serves as coordinator. The XBee network carries data from glove to computer based on serial communication.

Finally, the software framework is built in Grasshopper environment. Grasshopper is a graphical algorithm editor tightly integrated with Rhino's 3-D modeling tools. A VB component, called VB listener, developed by Andy Payne, in Grasshopper gets data from serial port, and, another visual C# component determines data relate to which parameter. There are many components in Grasshopper definition, designed for this project, that interpret data for controlling the model. Using Grasshopper gives the user opportunity to easily change interpretation process of data based on his or her needs.

In following sections, building glove and XBee network have been explained. The software framework, including Arduino sketch, Grasshopper definition, and many other projects and fun stuff can be found on: http://mtifall09.wordpress.com/

3-Materials, tools, and software

These parts are the exact parts used in this particular project. Any other similar part can be used instead of these. In addition, please take note that links are just provided to help you specify exact electronics used in this project, and it is not even a suggestion to buy from particular provider. There are many other sources that you can provide these materials.

1- LilyPad Arduino 328 Main Board – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=9266

2- LilyPad XBee Shield – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=8937

3- Polymer Lithium Ion Batteries 860mAh -1X
http://www.sparkfun.com/commerce/product_info.php?products_id=341

4- LilyPad LiPower – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=8786

5- XBee 2mW Series 2.5 Chip Antenna - 2X -
http://www.sparkfun.com/commerce/product_info.php?products_id=8691

6- Conductive Thread - 117/17 2ply – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=8544

7- LilyPad Accelerometer ADXL335 – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=9267

8- XBIB-U-ND (XBee Explorer USB by Sparkfun does the same much cheaper) – 1X
http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=XBIB-U-ND or
http://www.sparkfun.com/commerce/product_info.php?products_id=8687

9- USB miniB Cable – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=598

10- USB Cable A to B – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=513

11- FTDI Basic Breakout - 5V – 1X
http://www.sparkfun.com/commerce/product_info.php?products_id=9115

12- Band Sensor – 3X
http://www.sparkfun.com/commerce/product_info.php?products_id=8606

13- black, red, and another color “20 gauge” jumper wires

14- 220 Ohm resistor – 3X

15- 10 kOhm resistor – 3X

16- a multi layer glove with small pocket on top

17- a needle

18- non-conductive fabric thread

19- a piece of fabric – not bigger than hand palm

20- a fabric marker

21- a pair of scissors

22- a bottle of puffy fabric paint

23- a bottle of fabric glue

24- a soldering iron and lead-free solder

25- aluminum foil

26- a digital multimeter

27- a wire Stripper

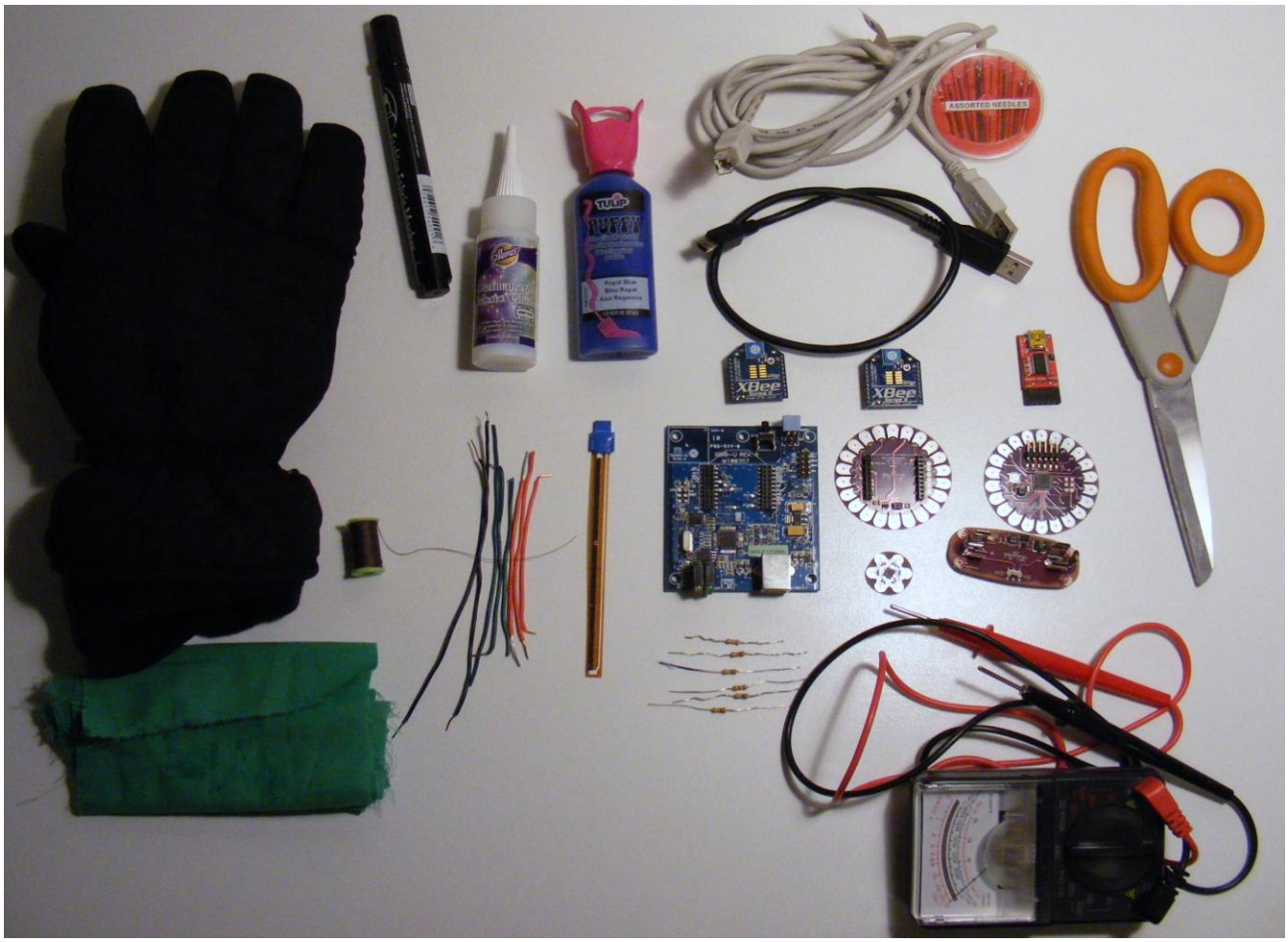
28- a pair of needle nose pliers

29- Rhino 3D – (You can download it here: http://www.rhino3d.com/download.htm)

30- Arduino software – (You can download it here: http://arduino.cc/en/Main/Software)

31- Grasshopper for Rhino 3D - (You can download it here: http://www.grasshopper3d.com/page/download-1)

32- X – CTU for establishing wireless network – (You can download it here: http://x-ctu.software.informer.com/)



4-Building the glove

Before Starting, please pay attention to following notes:

- If you are new to LilyPad, read this important note about connecting a LilyPad Arduino board to power supply here: http://web.media.mit.edu/~leah/LilyPad/build.html

- Check every connection by digital multimeter after sewing or soldering.

0- Separate most outer layer of glove by cutting its edges, using scissor - look at following image.

1- Shear 6 pieces of 2” long jumper wires and strip them.

2- Using needle nose pliers roll an end of stripped wires around a nail to make following form.

3- Connect formed wires to end of bend sensors.

4- Notch index finger connection with glove.

5- Push bend sensor into the crack.

6 – Connect round end of wire to glove by sewing using non-conductive thread. You can find information on sewing here: http://www.instructables.com/id/How-to-Sew./

7- Repeat 4, 5, and 6 for middle and ring fingers.

8- Stabilize LilyPad Arduino board, LilyPad LiPower, LilyPad XBee shield, and LilyPad accelerometer on glove separated layer, by gluing and sewing, regarding the following image.

Be sure that final position of LilyPad accelerometer will be horizontal when user put on the glove.

9- Sew power supply positive pole of LilyPad LiPower to LilyPad Arduino board, LilyPad XBee shield, LilyPad Accelerometer, and bend sensors, using conductive thread.

10- Insulate conductive threads using fabric glue and puffy fabric paint.

11- Sew LilyPad Arduino board TX port to LilyPad Xbee shield, using conductive thread.

12- Attach a piece of fabric on the back of glove separated layer using fabric glue in order to cover all conductive threads.

13– Shear and attach a piece aluminum foil on glued fabric. It provides a general conductive shield. Sew ground port of LilyPad Arduino board, LilyPad LiPower, LilyPad XBee shield, and LilyPad accelerometer to aluminum foil. By this a common ground has been provided for the glove circuit.

14- Bind glove separated layer to glove by sewing, use non-conductive thread.

15- Solder wire jumpers connecting LilyPad accelerometer X, Y, Z port to LilyPad Arduino board a0, a1, a2 ports in specified sequence.

16- Connect free end of bend sensors to ground and a3, a4, a5 ports on LilyPad Arduino board by soldering wire jumpers and resistors. Consider circuit sketch provided on next page to finish building glove.

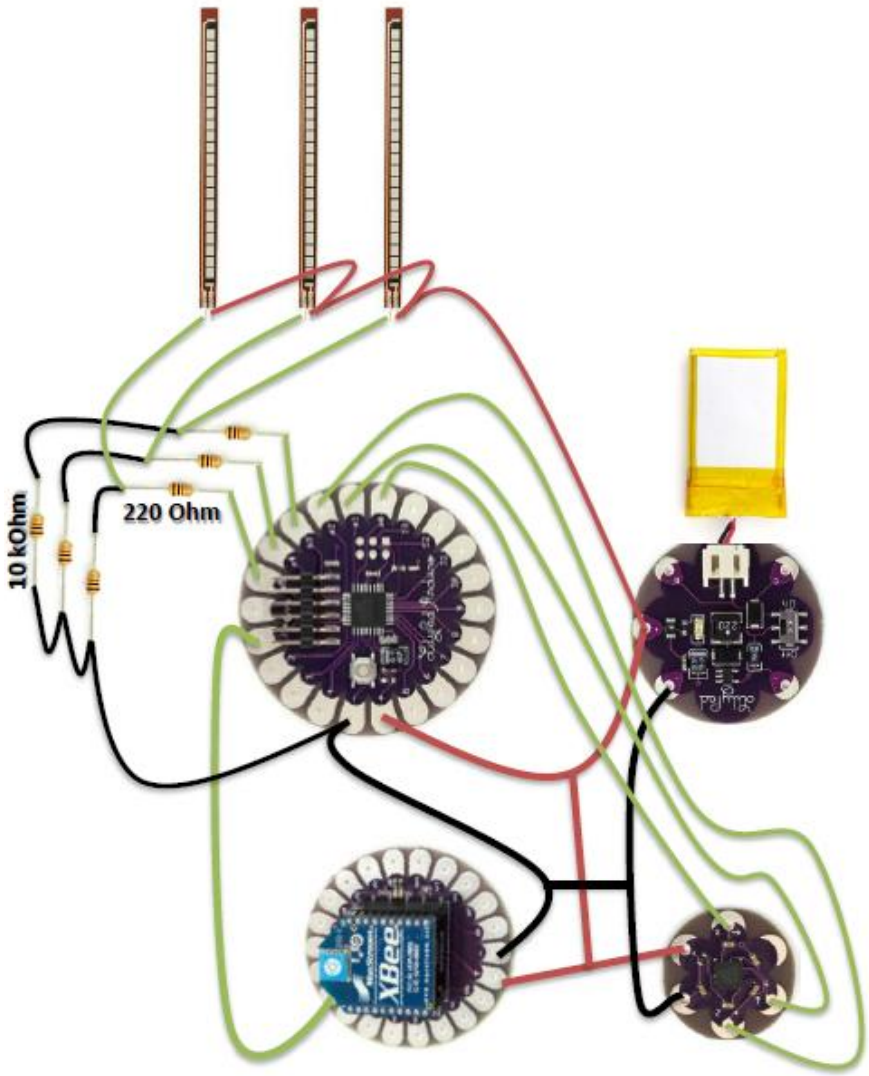
17- Clear all the dirt using a razor, and paint remaining stains using fabric marker.

18- Upload Arduino sketch to LilyPad Arduino board, by connecting it to computer using FTDI break out and USB cable.

19- Disconnect FTDI break out, connect rechargeable battery to LilyPad LiPower, and put battery in glove pocket.

20- Finally, establish wireless network as described in the following section.

Now, run Rhino 3D, run Grasshopper, load rhinoglove.ghx Grasshopper definition, and follow instructions inside the definition. The cubic box in rhino views should change based on your hand movements, as described in “Description” section.



5-Connecting Wirelessly

The communication between glove and computer is based on a serial communication using XBee wireless network. Procedure for establishing a XBee network is simple and straightforward. A good step by step setup procedure can be found here: http://www.humboldt.edu/~cm19/XBee%20setup.pdf

In this case, router XBee is the XBee module mounted on glove, and, XBee module connected to computer is the coordinator. In addition, both XBee module PAN network ID should be same. Finally be careful working with XBee module, it is very sensitive to power voltage. Overloading it by more than 3.7V power supply or connecting it to a power supply without a power supply regulator can easily burn the unit.

6-Coding

Please find Arduino sketch and Grasshopper definition of the project here:

http://code.arc.cmu.edu/~cheng/uploads/RhinoGloveSketch.pde

7-Demonstration

Please find video of Rhino Glove in action here:

http://www.youtube.com/watch?v=6A5I48RLtx4

8-Future work

The idea of manipulating glove is not a new idea but using it for creating architectural models has not been explored very frequently. Current software framework those not support hand rotation recognition. In addition, the interaction of framework with user's hand movements is weak and unsatisfying. Adding and improving these deficiencies could be near future goals. Also, adding another glove to give user further ability to control model in a 3D space could be a near future goal. Approaching a comprehensive wireless environment for controlling 3D modeling and even 3D fabrication could be a further future goals of this project.

9-Acknowledge

In general, I want to acknowledge CODE Lab, School of Architecture, Carnegie Mellon University for supporting my project by providing required knowledge and materials.

In particular, I want to thank

Cheng, our great TA, for always being there for answering questions,

Michel for sharing his vast knowledge,

and Prof. Mark Gross for his intellectual and academic support.

10-Resources

1- http://mtifall09.wordpress.com/ - Making Things Interact course blog

2- http://web.media.mit.edu/~leah/LilyPad/index.html - reference for LilyPad Arduino

3- http://www.arduino.cc/ - reference for Arduino hardware and software

4- http://www.instructables.com/ - useful guides for building things