# “Extended Reach” Haptic Array

Project Proposal

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Nathan Murray
Todd Pixton

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TA: Lydia Majure

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# Introduction

## Description

The motivation for this project stems from a desire to extend and expand human sensory perception. There are many signals that humans simply don't have the capacity to sense; ultrasound, infrasound, the vast majority of the electromagnetic spectrum, and the temperature of distant objects are all invisible to humans. Our project aims to allow humans to experience these signals by translating them into a form that humans can recognize.

Specifically, this project will provide the tools to map any quantified characteristics of a signal detected by a sensor into a haptic response on an arm-worn array of motors. This haptic feedback system will use an array of micro-transducers to stimulate the user's arm, utilizing the body's haptic perception of different intensities, locations (two dimensions), and frequencies. Every tenth of a second, the haptic device will accept a packet of information from the sensor. This packet will give values for up to three signal characteristics, which will then be intelligently mapped to haptic intensity, location, and frequency. The mapping will be modular and easy to use; the user will have the ability to decide what signal characteristic gets mapped to each haptic quality. The end result will be a "natural" psychophysical stimulus to a signal imperceivable to humans.

This project is a continuation from a previous semester's project (60 Hz Electromagnetic Field Detector/Interface System). We are focusing on improving the haptic array. The previous project's haptic array was only capable of changing intensity, and was also flimsy. We aim to expand the haptic stimulus to include location and frequency, and use durable build techniques for a robust haptic device.

## Benefits

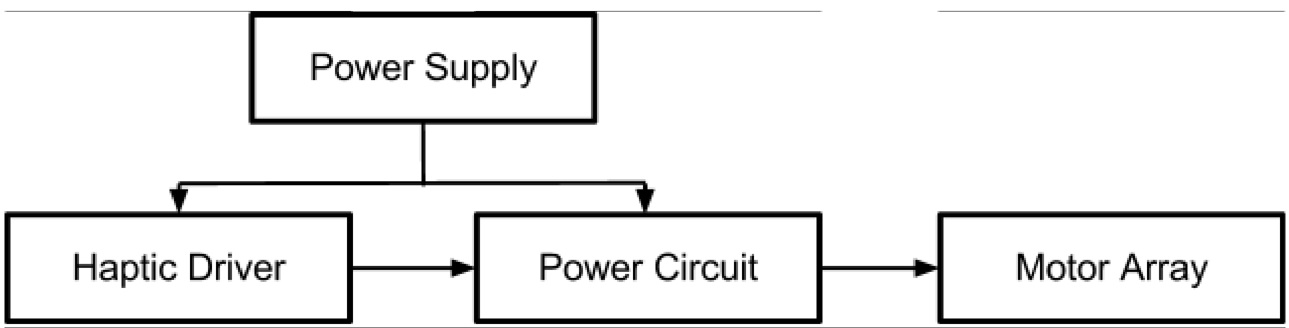
- Augments human sensory perception
- Delivers "natural" psychophysical haptic feedback
- Provides four dimensions of biofeedback (intensity, frequency, x/y location)
- Modular device driver works with any quantified signal characteristics
- Unobtrusive haptic feedback works in noisy and bright environments.
- Modularity allows expansion and integration into other human augmentation designs

## Features

- Arm-worn haptic feedback array
    - Sturdy, compact design
    - Four dimensions of haptic feedback
- Haptic feedback driver with simple programmable interfacing with signal characteristics
    - Modular, simple user interface
    - Supports any quantifiable signal qualities

# Design

## Block Diagram




## Block Descriptions

**Power Supply:** Power will be supplied by DC battery sources.
Inputs: None
Outputs: 5V and 9V DC

**Haptic Driver:** A microcontroller will take in quantified signal characteristics and map these characteristics to haptic features of the array. PWM values for every motor will be calculated to achieve the haptic stimulus.
Inputs: 9V DC
UART data from sensor
Outputs: PWM signals for every motor

**Power Circuit:** The power circuit will amplify the PWM signals from the Haptic Driver such that they can be used to drive the motor array. Transistors will be used for amplification.

Inputs: 5V DC
PWM signals from Haptic Driver
Outputs: Amplified PWM signals for every motor

**Motor Array:** The motor array will be two 7x4 arrays of shaftless vibration motors (one for the top of the forearm, and one for the bottom). The motors will be secured in a robust armband.

Inputs: Amplified PWM signals from Power Circuit
Outputs: Haptic stimulus on user's arm

## Performance Requirements

- Achieve a robust device by employing durable build techniques
- Achieve continuous perception (motors indistinguishable from one another)
- Achieve large range of frequency and intensity for a wide range of stimulus

# Verification

## Testing Procedure

Every block in the above diagram will need to be tested for completeness and operability. Each block will also need to be tested with the other blocks to make sure that the entire system works as a whole. In order to test the Haptic Driver, we will use a simple test that will cause all of the PWM signal outputs to exercise their full range of intensity and frequency, which we will then measure for correctness using an oscilloscope. For the Power Circuit block, we will supply input signals from a function generator and measure the output signals using an oscilloscope to ensure that they are being amplified correctly. For the Motor Array block, we will use a function generator to test the boundaries of motor behavior, and eventually test the functionality of the entire array after the previous blocks have been constructed and tested.

Robust design techniques will be evaluated for their durability, such that we can ensure a robust design.

## Tolerance Analysis

The Power Circuit block for this project must work to a tight tolerance. The motors can not run when powered by the Arduino. The motors require more current than the Arduino can supply without burning out. For this reason, we need to ensure that the Power Circuit block is capable of amplifying the signals from the Arduino into the range of operation for the motors.

In order to verify that the Power Circuit block works as intended, we will need to subject it to a variety of PWM signal scenarios and measure the output. We will then analyze the output signals to confirm that they conform to the acceptable range of inputs for the motors.

# Cost And Schedule

## Cost Analysis

### Labor Cost

| Billable Hours Per Week Per Engineer | Weeks Of Contract Per Engineer | Total Billable Hours Per Engineer | Multiplicity Factor | Per Hour Billing Rate Per Person | Total Contract Cost |
|---|---|---|---|---|---|
| 9 | 13 | 117 | 2.5 | $34.00 | $9,945.00 |
| No. Of Engineers in Team | | | | | 2 |
| Total Labor Cost of Project | | | | | $19,890 |

### Parts Cost

| Part | Quantity | Unit Cost | Total Cost + Shipping |
|---|---|---|---|
| Shaftless Vibration Motor 8x3.4mm | 50 | $2.79 | $146.45 |
| Arduino Uno | 1 | $29.95 | $33.59 |
| TI TLC5941 16-Channel LED Driver | 2 | $2.32 | $12.64 |
| 22 Gauge Wire | 10 ft | $0.30/ft | $3.00 |
| Resistors | 10 | $0.10 | $1.00 |
| 9V Battery | 12 | $1.40 | $16.80 |
| AA Battery | 20 | $0.32 | $6.49 |
| **Total Parts Cost** | | | **$217.97** |

Total Cost of Project: $20,109.97

## Schedule

| Week | Date | Task | Member Responsible |
|---|---|---|---|
| 1 | 9/10/2012 | Write Proposal | Both |
| | | Haptic Array Design | Nathan Murray |
| | | Haptic Driver Design | Todd Pixton |
| 2 | 9/17/2012 | Decide Array Parts | Nathan Murray |
| | | Design Sensor Interface | Todd Pixton |
| 3 | 9/24/2012 | Order Power/Motor Parts | Nathan Murray |
| | | Order Arduino, Interface Parts | Todd Pixton |
| | | Design Review | Nathan, Todd |
| 4 | 10/01/2012 | Build Power Circuit | Nathan Murray |
| | | Build Arduino Interface, Testing Code | Todd Pixton |
| 5 | 10/08/2012 | Build Motor Array | Nathan Murray |
| | | Test Motors with Arduino | Todd Pixton |
| 6 | 10/15/2012 | Signal Group Communication Collab. | Nathan Murray |
| | | Code Motor Interface Protocols | Todd PIxton |
| 7 | 10/22/2012 | Build Arduino Enclosure | Todd Pixton |
| | | Build Motor Array Enclosure | Nathan Murray |
| 8 | 10/29/2012 | Test Connections and Functionality | Nathan, Todd |
| 9 | 11/05/2012 | Mock Up Demo | Nathan, Todd |
| | | | |
| 10 | 11/12/2012 | Mock Presentations | Nathan, Todd |

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|---|---|---|---|
| 11 | 11/19/2012 | Thanksgiving break | |
| 12 | 11/26/2012 | Resolve Problems from Mock Ups | Nathan, Todd |
| | | Prepare Presentation | Nathan Murray |
| | | Prepare Final Paper | Todd Pixton |
| 13 | 12/03/2012 | Demo | Todd PIxton |
| | | Presentation | Nathan Murray |
| 14 | 12/10/2012 | Final Paper | Nathan, Todd |