# *Vibro-Vest: Directional Information in Three Dimensions*

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## Introduction

Many situations involve high dependence on visual input in order to safely and effectively operate machinery or navigate a high stress environment. As a result of this overstimulation, the decision making ability can be degraded constituting a risk for the subject. To address this issue, another mean of communicating information to the operator has been developed: Vibro-vest is able to convey directional information to operators whose visual channels are near overload and whose tasks involve 3D awareness (i.e. flying), as opposed to planar awareness (i.e. driving).

## Motivation

The Vibro-vest would be able to:

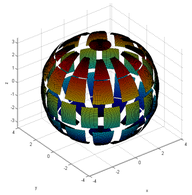
- Transmit navigation information in 3-D via sensory channel
- Increase maneuverability and dexterity when operating in 3-D environments
- Reduce risk to operators with saturated visual input

## Vibro-Vest Design

- Vibro-vest will use an array of vibrotactors placed on both the front and back of the torso
- The locations of the vibrotactors are determined by the “tap-on-the-shoulder” principle, which states that stimuli on the torso can represent directions to be followed: front is front, left is left, etc.
- Vibrotactors will be controlled by a control board programmed in C++ language.

**Resolution of Vibration**

The Vibro-vest will have a total of 66 combinations of vibrations that will determine the same amount different directions.



- The sections of the exploded sphere show the individual angular regions that can be identified through the combination of the vibrating motors.
- Users would be able to identify each of the angular regions

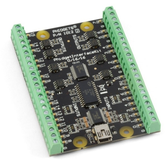
- 16 vibrotactors were added to the vest and were distributed as shown in the figure. The back side of the vest has the same pattern
- A total of 66 angular regions can be encoded using combinations of vibrating vibrotactors
  - The vibrating combinations and locations of the vibrotactors were determined using haptic perception theories: the direction indicated by two vibrating motors will be the midpoint between them

Advantages of Pancake Vibrating Motors:

- Low price
- High vibrating frequency
- Low voltage needed to operate

Disadvantages:

- Short and delicate connecting cables
- Overheating



Advantages of Phidget Interface Kit control board:

- Low price
- Compatible with C++ language
- Able to power programmed combinations of vibrotactors

Disadvantages:

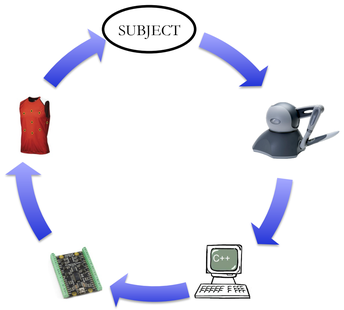
- Non-variable voltage output

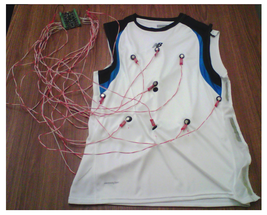
- The Phantom Omni was used for the familiarization stage of the experiment
- The pointer position of the Phantom Omni determined the vibrating angular regions

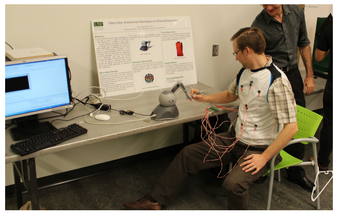
## Experiment

- All male subjects
- Subjects between 25 and 35 years old

**Part 1: Familiarization with the device**

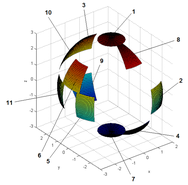




- Each subject was fitted with the Vibro-vest and asked to manipulate the Phantom Omni in order to familiarize with the resolution of the angular regions
- The loop shows the flow of information, starting at the subject and ending on the Vibro-vest

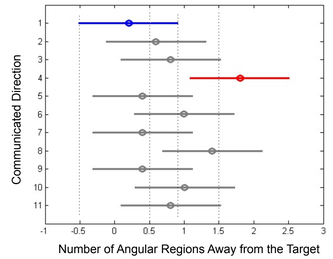
**Part 2: Testing**



- Subjects were given a ball which detailed and numbered each angular region
- 11 Programmed separate spatial directions were communicated through the vest
- Subjects were asked to indicate the direction that they perceived from the Vibro-vest using the ball


- Programmed angular regions were communicated from the computer to the subject without any noticeable loop
- All subjects were tested using the same sequence of angular regions

## Results




- The ANOVA results on the left show that most subjects interpreted the vibrations within an average of 0.3 to 1 angular regions away from the communicated one
- Results agree well with the haptics perception theories:
  - Tap on the shoulder, which indicates that localized vibrations on the torso can transmit directional information
  - The direction indicated by two vibrating motors will be the midpoint between them

## Conclusions and Future Work

- A novel technique of communicating spatial information in 3-D was presented
- The tested design succeeded in achieving an intuitive perception of spatial direction; however, further design optimizations are necessary in order to communicate spatial information in a better way:
  - Earphones can be given to the subjects to block audible perception of the vibrating motors
  - Improve the wire isolation since vibrating wires gave false directional information to the subjects

## Applications

- Development of a navigation system that helps to reduce visual overstimulation for operators whose visual channels are approaching overload like:
  - Combat pilots
  - Crane operators
  - UAV pilots
- Warning system of external threats for the mentioned operators
- Navigation system for visually impaired individuals
- Entertainment:
  - Video games application

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