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October 29, 2002

Dr. Andrew Rawicz
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Simon Fraser University
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Re: Design Specifications for the TactiVision Tactile Interface

Dear Dr. Rawicz,

Pursuant to the *TactiVision* functional specifications revision 1.1 of October 17, 2002, the enclosed document *Design Specifications for the TactiVision Tactile Interface* outline Vindica Systems' ENSC 340 project design specifications.

TactiVision is a device that will enable the blind to interact more freely with their surroundings by converting visual details to a touch-oriented format. These design specifications describe how the functional requirements of each *TactiVision* subsystem will be met.

If you have any questions about the project or these design specifications please feel free to contact me at (604) 936-9699 or troy@vindica.ca.

Sincerely,

Troy Tyler
President and CEO
Vindica Systems Inc

Vindica Systems Inc.

Design Specifications for the TactiVision Tactile Interface

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Submitted To

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Revision

1.1 - October 26, 2002

Executive Summary

Advances in real-time imaging technologies are bringing the possibilities for alternative visualization devices ever closer to realization. Consequently, the demand for inexpensive tactile displays is increasing. Although we at Vindica Systems aspire to meet this demand with our *TactiVision* tactile display unit, the full potential of this device cannot be fully realized within the scope of this course.

Here at Vindica Systems, we are focusing on designing a low cost, integrated version of the tactile display. Achievements in those areas, however, must not detrimentally affect the overall performance of the device.

The details concerning the design of the proof-of-concept requirements have been closely scrutinized to produce the *TactiVision* design specifications that follow. The design of the *TactiVision* has been broken up into three separate subsections. These subsections are the software visual user interface, the controller hardware, and the tactile user interface.

Vindica Systems' timeline for completion of the project is intact, and we are confident that we will be demonstrating the *TactiVision* prototype in early December of this year.

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1. Introduction

The *TactiVision* functional specifications set forth in *Functional Specifications for the TactiVision Tactile Interface* have been used to develop these design specifications. The functional specifications were broken into two system levels consisting of a prototype version (Level I requirements) and a production version (Level II requirements). Since our current project goal is the development of a working prototype, these design specifications are concerned with only the requirements that pertain to the Level I system.

1.1 Scope

The specifications set forth in this document comprise the design requirements of the blind-assist tactile display system previously introduced in the project proposal entitled *Proposal for a Blind-Assist Tactile Interface.*

1.2 Audience

This document was written for product managers and design engineers as a reference for the development of the *Tactivision* blind-assist tactile interface. Product mangers will use this document to assign project tasks, and define goals and timelines. These specifications also act as a basis for the managers to assess the viability of the project throughout its development.

1.3 Document Conventions

The tactile display system is most easily conceptualized as an integration of three interdependent subsystems. The subsystems consist of the visual-information interface, the control hardware and the tactile interface. Each of the requirements has been bulleted with one of the following requirement types:

- Operating Condition
- Reliability
- Compatibility
- Power Consumption
- Heat Dissipation
- Safety Features
- Measurement
- Packaging
- User Interface

2. System Specifications

The tactile display system design specifications are subject to two requirement levels, as mentioned in the functional specification document conventions. Level I is comprised of the minimum requirements and test criteria to which the proof-of-concept prototype *TactiVision* system will be held. Again, the Level II specifications are not addressed in this document.

2.1 System Overview

The *TactiVision* system overview is illustrated in *Figure 1*. Each of the subsystems has been clearly defined, and has its own set of interdependent design specifications detailed in the following sections.

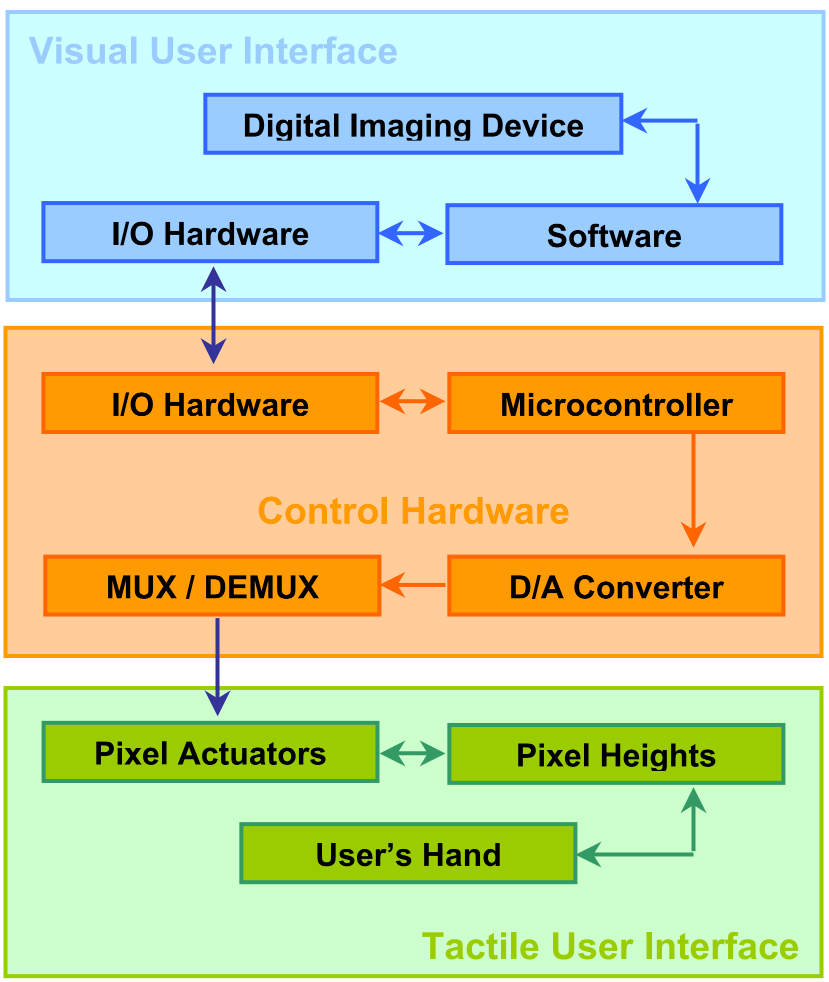

Figure 1 ~ TactiVision system block-diagram

2.2 Level I System

Each of the components used in the control hardware and tactile user interface subsystems operates within the temperature and relative humidity ranges specified by requirements I.00 and I.01 respectively. The pixel actuator (nitinol) is highly temperature sensitive, therefore the heat it generates when activated must be dissipated through convection cooling. Heat dissipation requirement I.43 will be met through the inclusion of a small computer fan within the tactile interface enclosure in addition to several ventilation slots.

The current / power requirements of the *TactiVision* system are substantial in comparison to most computer peripheral electronics devices. Since the intended use of the prototype device is in a desktop environment the amount of electromagnetic interference (EMI) it generates must be minimized, as must its susceptibility to outside sources of interference, in accordance with requirements I.03 and I.04 respectively. If the EMI or sensitivity of the system is later determined to warrant magnetic shielding, the tactile interface enclosure will be lined with aluminum foil or a suitable alternative.

In the event of any unforeseeable loss of system integrity (i.e. overheating, fluid contaminants) addressed by functional requirement I.04, the user will be able to quickly deactivate the tactile interface hardware through either a software-embedded or a physical emergency stop button. Activating either of these mechanisms will immediately disconnect the tactile pixel actuators and logic networks from the power supply.

2.2.1 Visual User Interface

The visual user interface (the software) will be a win-32 executable written in Microsoft Visual C++ 6.0 which will make it compatible with Microsoft Windows 95 / 98 / 2000 / Me / NT / XP operating systems, thereby satisfying requirement I.06 of the functional specifications.

The software will meet system requirements I.07, I.08, I.09 and I.12 by taking the 8-bit greyscale values for each pixel in the selection area and sequentially transmitting them to the control hardware input register via the computer's serial / USB port, using universal asynchronous receiver transmitter (UART) protocol at a rate to be determined by the acquisition capabilities of the microcontroller.

Figure 2 has been included to illustrate the basic design aspects of the preliminary visual user interface. Functional requirements I.11 through I.16 will be met through the use of the simple click-based mouse commands within the program window.

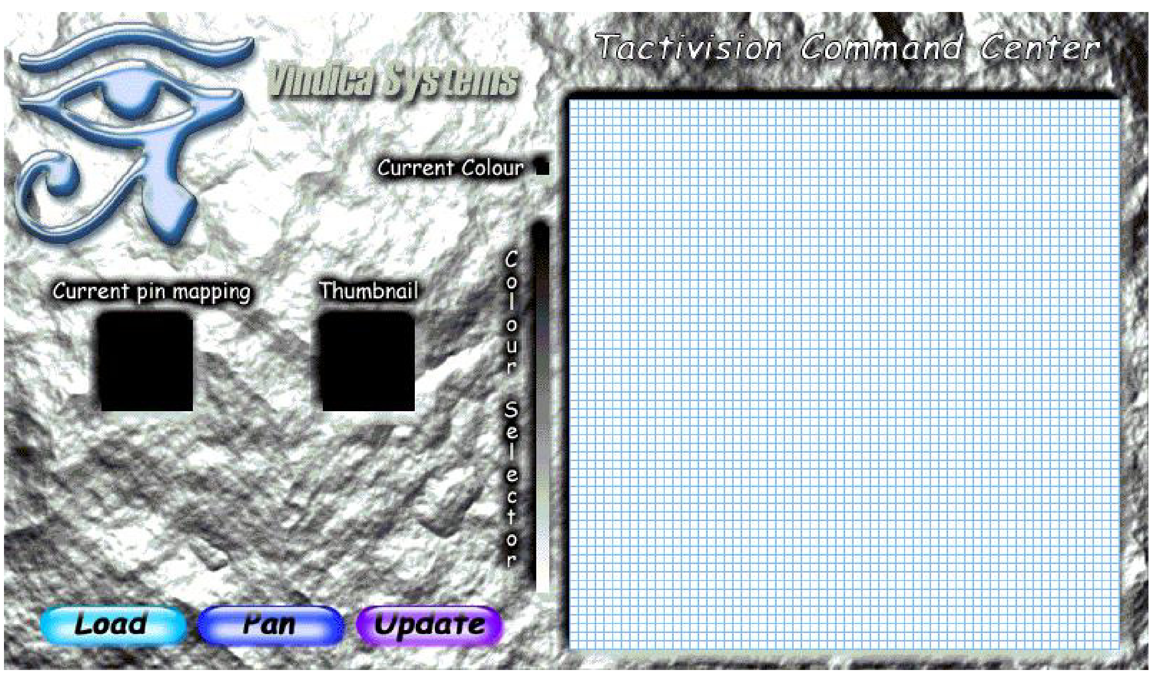

Figure 2 ~ TactiVision Visual User Interface Design

The 'Load' button of Figure 2 will initiate the familiar Windows File-Open dialog box, prompting the user to browse the file system for Windows bitmap type files. Upon selection of an image, the dialog box will close and the image will appear in the edit and thumbnail windows, as per functional specification I.11.

Functional requirement I.13 will be met through the use of the 'Color Selector' frame of Figure 2. The user will be able to select any of 256 shades of grey by clicking on the desired intensity in the gradient panel. The current color will be updated and shown in the 'Current Color' frame.

Clicking on the 'Pan' button of Figure 2 will engage an outlined selection tool that prompts the user to enclose the area of the enlarged image that is to be output to the tactile interface. Once an area has been selected, the 'Current pin mapping' frame will be updated with the contents of the selected image area in accordance with functional requirement I.14.

Users will be able to output the current pin mapping to the tactile display by clicking the 'Update' button shown in Figure 2. When testing requirement I.15 of the visual user interface subsystem, it may prove that updating the tactile display automatically is more convenient for the user, in which case the display will update upon selection of the new pin mapping area.

2.2.2 Control Hardware

The control hardware will consist of solid-state semiconductor technology mounted on a printed circuit board (PCB), allowing the system to continue functioning when rotated or inverted, as specified by functional requirement I.17.

Inputs from the visual user interface will be received through the serial port using universal asynchronous receiver transmitter protocol in accordance with specifications I.18, I.19, I.20 and I.21. Bytes represent corresponding pin heights and are stored in on-chip memory whenever the pin mapping is updated.

Upon receiving the updated pin mappings, the microcontroller will refresh the tactile display's latched, voltage-controlled current-sources at each pin. This will be accomplished by sequentially performing color-to-voltage scaling ALU operations on the pixel color values stored in memory and outputting this value to the digital to analog (D/A) converter. The analog voltage from the D/A will appear at the drain of each transistor in the array, leaving the task of selective latching to the microcontroller. As each new D/A value is sent, the controller will also increment a 6-bit output counter that is connected to the pin demultiplexer and controls which of the latches will store the incoming D/A value. The detailed design specifications of the actuator hardware are included in Section 2.2.3.

The control hardware specifications I.24 through I.26 are to be met through the use of a 10W 5A wall outlet adapter that is shared by both the control hardware and the tactile interface. The MC68HC11 microcontroller being used consumes less than 150mW at room temperature, and the supply rail will be capacitively coupled to ground adjacent to the microcontroller supply input pins to eliminate transients.

2.2.3 Tactile User Interface

The Tactile User Interface subsection of the *TactiVision* will be composed of the functional blocks shown in Figure 3.

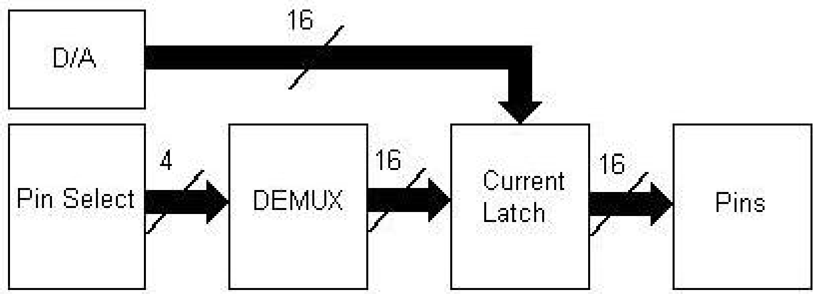

Figure 3 ~ Block Diagram of the Tactile User Interface

The height of the pins will be adjusted by varying the current run through their muscle wire actuators, which is in turn controlled by the voltage coming from the D/A. A signal is received from the microcontroller that, after demultiplexing, determines which pin actively receives the voltage from the D/A. A received voltage will be maintained through the use of a latch circuit and a current mirror that will provide a steady current through the muscle wire until a new voltage is received from the D/A. Figure 4 shows the schematic for this circuit.

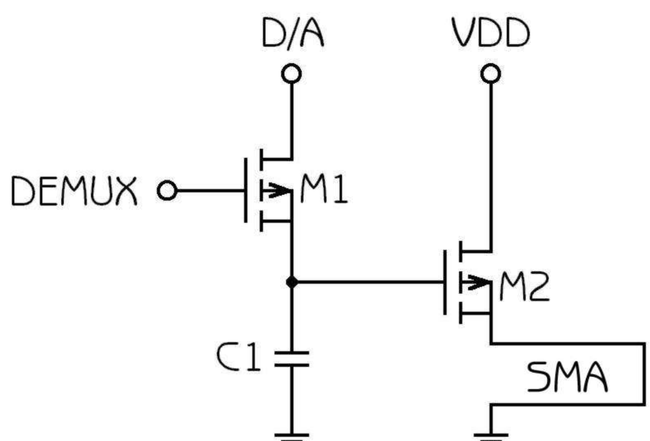

Figure 4 ~ Circuit used for latching the current

If time permits, we will construct a 64 pin-array. However, it is much more likely that we will only have time to construct a small number of pins, so for now we will focus on a more attainable goal of a 16-pin array. For the 16 pin-array, we will use two 3-to-8 demultiplexers. The 64-pin array would require eight of these. Also, each pin will require an identical current latch circuit. We will be constructing a single PCB to house the 16 current latches as well as the demultiplexers.

The pins will be constructed using hexagonal rods, springs, and muscle wire. We are using a hexagonal shape for the pins because a hexagonal shape allows the user to feel differences in height between a single pin and the six surrounding pins versus four using squares. This advantage can be seen in Figures 5 and 6.

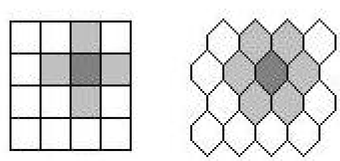

Figure 5 ~ Comparison between square and hexagonal pin-arrays

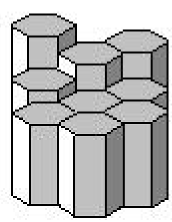

Figure 6 ~ 3 Dimensional view of pins at different heights

The default position for the pins will be up, and they will be held in this position by a spring attached between the bottom of the rod and the pin layer, as shown in Figure 7. The muscle wire is shown as a red line connecting between the hexagonal rods and the pin layer, which is shown in blue. Wires will connect the muscle wire to the PCB so that a current may flow through it.

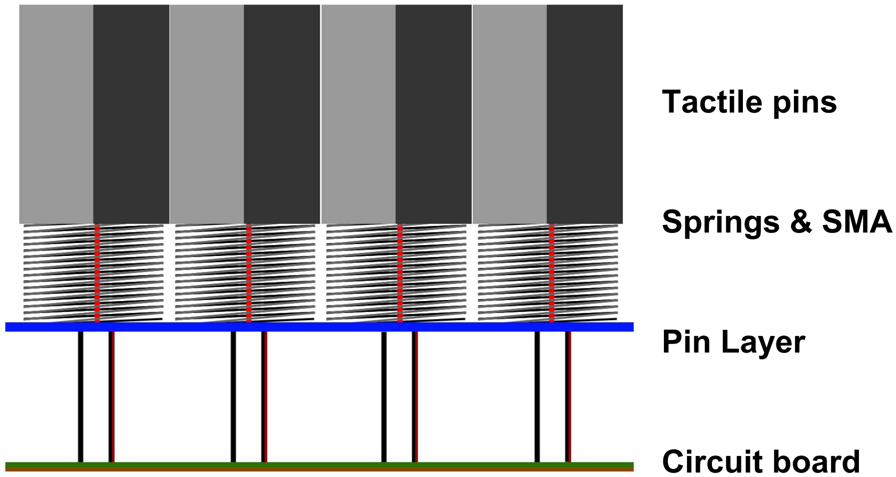

Figure 7 ~ Side view of pins

The spring will also supply a restoring force to return the pins to their natural position when they are inactive. Muscle wire will also be connected to the bottom of each rod and the pin layer, and will pull the pins down when a current is run through it. Figure 8 shows a close-up of one of the pins. The muscle wire is again shown in red. This design allows for very minute changes in pin height to be detected, and also is stable enough that a hand resting on it will not displace the pins, as stated in requirements I.52 and I.53.

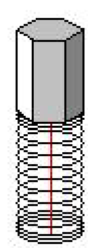

Figure 8 ~ Close-up of single pin

The muscle wire selected for this project will last for roughly 1,000,000 cycles if used in a range of 3-5% compression. If it is used at 10% compression, however, it will only last for about 5 cycles. In order to meet requirement I.37, we will not use compression of greater than 5%. This means that in order to achieve a vertical displacement of 2 mm, in accordance with requirement I.51, a length of 40 mm is required. Requirements I.40 through I.42 will be met by using the power supply described in Section 2.2.2. This will be sufficient to drive all 16 pins at maximum displacement.

The enclosure will be made out of plastic and fit snuggly around the pins. It will have room for the pin-array, the PCB, the controller hardware, and the power supply. This complies with requirements I.48 and I.49. If heat becomes a problem within the enclosure, fans will be installed to maintain a temperature of less than 45°C, as stated in requirement I.43.

4. Prototype Test Plan

This section outlines the test processes that we will implement to test the Level I functions presented in this document.

4.1 Installation

4.1.1 The user shall plug the Tactivision into the wall socket and connect it to the computer.
4.1.2 The user shall install the Tactivision software onto a PC running Windows 95 / 98 / 2000 / NT / Me / XP.

4.2 Visual User Interface

4.2.1 The user shall push the software emergency stop.
4.2.2 The user shall load an image into the VUI.
4.2.3 The user shall draw/edit an image using the drawing functions.
4.2.4 The user shall select the current pixels that are to be mapped to the TUI using the pan option.
4.2.5 The user shall update the pixels of the TUI using the software.

4.3 Control Hardware

4.3.1 Every possible input / output combination shall be scrutinized for speed and accuracy.
4.3.2 The time for the current to drop by 10% of the desired latched value shall be tested in the lab.
4.3.3 The CH shall be subjected to contamination by foreign materials including dust, dirt and food while operational.

4.4 Tactile User Interface

4.4.1 The user shall push the hardware emergency stop button.

4.4.2 Vertical displacements of .1 mm between neighboring pixels will be hand checked for vertical resolution.

4.4.3 The user shall identify simple test objects on the TUI by touch only.

4.4.4 The pixels will be actuated randomly at the maximum speed for 24 hours, subjecting each pixel to no fewer than 10,000 cycles.

4.4.5 The pixels shall remain fully actuated for 24 hours.

4.4.6 The TUI shall be tested at the extremities of the normal operating conditions.

4.4.7 The pixels shall be subjected to constant pressure as well as impulses of pressure, and they shall be monitored for strain.

5. Conclusion

Vindica Systems has developed these design specifications to define the implementation of the functional requirements of the Level I *TactiVision* system. The success of the company in this endeavour shall be measured by our ability to meet each of the system test requirements specified in the prototype test plan.

We are determined to find an economically viable solution to the design and cost problems currently faced by potential users of tactile displays. We are on course to complete of a prototype version of the *TactiVision* system by early December.

8. References

www.csa.ca	Canadian Standards Association
www.fcc.gov	Federal Communications Commission
www.iec.ch	International Electrotechnical Commission
www.ulc.ca	Underwriters' Laboratories of Canada