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February 19, 2007

Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
Canada

Re: ENSC 440 Functional Specifications for computer input device

Dear Dr. One:

The attached document, *Functional Specifications for a Handheld Computer Pointing Device*, outlines the functional specifications for ENSC 440. We are in the process of designing a handheld computer pointing device that moves the mouse cursor as the device moves in the corresponding direction, which enables users to operate in situations where flat surfaces are not available.

The objective of this document is to list the design parameters for which our device will be able to operate. This functional specifications document will include the specifications to be met by the end of April, and possible further specifications for future and final products.

Pointex consists of 5 motivated and dedicated senior SFU Engineering Science students: Frank Chen, Donavan Ho Sui, Randall Lim, Jeff Wong, and Kevin Yang. We can be contacted by e-mail at *ensc440-group-16@sfu.ca*.

Sincerely,

Frank Chen
CEO
Pointex

Enclosure: *Functional Specification for a Handheld Computer Pointing Device*

# *Functional Specifications for Handheld Computer Pointing Device*

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**Issued date:** February 19th, 2007
**Revision**: 1.0

# *Executive Summary*

The SmartPoint handheld computer input device is directed towards a market of computer users who wish to operate the mouse with precise control, such as graphic arts users, CAD designers, and artists. The controls of the mouse cursor that SmartPoint will achieve have not yet been met by any other present day mouse input devices. Therefore, it could be a benchmark for future technology whereby other products may use our system as a basis for operation.

The development of SmartPoint will occur in multiple stages. The beginning stages will include development of the basic foundation our product such as the underlying systems. Subsequent stages will use this underlying system and make further advancements or slightly alter the original design.

After the first stage of development, SmartPoint will:

- Move the mouse cursor corresponding to the movements of the user.
- Have the “left-click” and “right-click” functionality.
- Have a Lithium Ion rechargeable battery that comes with charger
- Be wireless.

Subsequent stages may include:

- A new gamer-intuitive mouse operating system.
- Wheel scrolling function.
- Indoor and Outdoor operating modes.
- Additional add-on buttons for easy web surfing.
- Implementing tilt sensors.

We estimate that the first stage of development for SmartPoint will be completed by April 2007.

 

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# *List of Acronyms*

**CAD**: Computer Aided Design

**CSA**: Canadian Standards Association

**EMI**: Electromagnetic Interference

**EMS**: Electromagnetic Stirring

**FCC**: Federal Communications Commission

**FPS**: Frames per Second

**IEC**: International Electrotechnical Commission

**LED**: Light Emitting Diode

**OpenCV**: Open Computer Vision

**PC**: Personal Computer

**RoHS**: Restriction of Hazardous Substances

**USB**: Universal Serial Bus

**UL**: Underwriters Laboratories Inc. (Standards for public Safety)

 

# 1. Introduction

Studies have shown that people working on laptops with an external mouse are much more productive, faster, and accurate than those working with the laptop's built-in touchpad or trackpoint. Unfortunately for people working in a predominantly outdoor field environment, such as geologists and biologists, flat surfaces required by mice are not readily available.

The objective of our project is to develop an alternative pointing device, SmartPoint, that these people can use without having to resort to their built-in pointing devices and compromise their productivity. The general idea is a handheld device that navigates the mouse cursor around the screen by pointing the device at the same location, much like video game light pistols.

In addition to workplace benefits, SmartPoint can also augment the computer gaming experience by providing a more immersive way of interacting with the game. Instead of using the traditional mouse to control the movements of an onscreen weapon, the user can experience the simulated sensation of holding an actual gun while pointing at the objects on the screen.

## 1.1 Scope

This document standardizes the functionalities to feature in the proof-of-concept and production of SmartPoint models. The list of functional requirements for the proof-of-concept model provides the guidelines for our design engineers. Since experience will be gained while developing this device, only a partial set of functional requirements is supplied for the production device.

## 1.2 Intended Audience

The primary audiences of this document are design engineers, integration engineers and quality assurance personnel. This document will be the guideline through which all module and system designs must comply.

Engineers and executives can use this document to plan, direct, motivate and monitor the development progress.

Marketing personnel can use this document to develop advertising materials.

 

### 1.3 Referenced Documents

[1] Proposal for a Handheld Computer Pointing Device. Pointex

### 1.4 Objectives

The following convention is used throughout the functional specification to indicate functional requirements:

R[#] A functional requirement.

A number (n) will be appended to each functional requirement to denote the priority of ach functional requirement. The symbol (n) signifies:

(1) A functional requirement for both the proof-of-concept prototype and the production device.

(2) A functional requirement for only the proof-of-concept prototype.

(3) A functional requirement for only the production device.

 

# 2. System Requirements

## 2.1 System Overview

Our system structure has a uni-directional flow of information. The user holds a mouse tracking device in his hand which transmits point reference signals to the webcam positioned above the display monitor. Based on the user's hand movement, the webcam peripheral interprets this transmitted data and moves the mouse pointer appropriately on the display monitor.

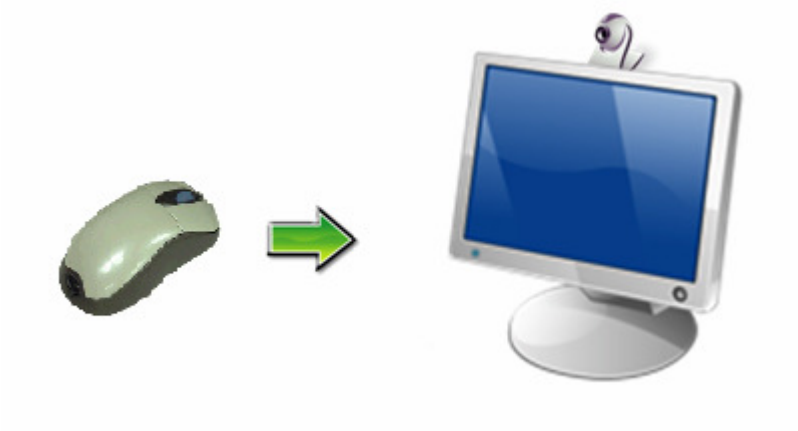

**Figure 1 Device System Overview**

## 2.2 Handheld Remote Subsystem

The handheld device subsystem will be small and portable. Motion movements by this device will be identified and tracked by the web camera and software subsystems. This subsystem will also contain buttons that the user will use in order to perform "left click" and "right click" operations, same as any ordinary computer mouse.

The web camera and software subsystem will move the mouse cursor corresponding to the user's hand motions, and is therefore responsible for relaying user input information to the PC. This subsystem emits a traceable reference marker, thus allowing the camera to identify and capture all user data. The data will be processed by the software subsystem. Pressing the "left click" and "right click" buttons will emit different reference markers, which will execute the corresponding clicks on the PC. Using the subsystem in this way allows for the remote to be completely wireless, without the need to send any radio-frequency signals.

 

### 2.3 Camera Subsystem

This product will require an input capture device to obtain images, having a minimum defined resolution and frame rate, to be sent to the software subsystem for processing. The resolution and frame rate of the camera subsystem will determine the performance characteristics of the mouse cursor, and also the amount of computing power required to process the images. However, an existing web camera would be sufficient in obtaining the necessary input from the handheld device which will then be sent to the PC for image processing.

### 2.4 Software Subsystem

The software subsystem is the system process the computer will use to analyze the images captured by the camera. The programs that will be used are Visual Studio C++ and OpenCV. There will be a number of required processes, of which each process will require a portion of the computing power. Each process is essential in analyzing the web camera images correctly and efficiently. The software subsystem will include processes such as: matrix calculations, mouse movement, image processing and colour subtraction.

The user may wish to position the mouse cursor in a way that requires that user to perform the least amount of hand movement. This means the user will tilt the device from a stationary point instead of dragging the device across the surface of the monitor. Therefore, the software subsystem will be required to calculate from the images both angles and tilt of the device, in order to determine pointing position on the display screen.

Image processing requires colour subtraction which enables object tracking in an efficient manner. Colour subtraction is a part of the image processing subsystem, whereby it cancels all other background colours except for the colour of the reference marker, thus making the marker tracking process much easier.

After the colour subtraction subsystem, there will be a much more simplified image left to be processed. The image processing subsystem includes all programs which analyze images sent from the web camera and determine the distance of reference marker movement. This information is then sent to the mouse movement subsystem. The mouse movement process will take the information of mouse displacement and possible mouse clicks, and communicate these commands to the PC.

 

# *3. Physical Requirements*

### 3.1 General Requirements

**R[1]** The prototype will operate in various types of indoor conditions ranging from low light to brightly lit areas. (3)

**R[2]** The webcam has to be centered on top of the monitor display for best performance. (2)

**R[3]** The webcam is powered by connecting it to PC via the USB port. (1)

**R[4]** The prototype will be powered by a Lithium-Ion battery cell. (1)

### 3.2 Functional Requirements

**R[5]** The onscreen mouse cursor must move in the same direction that the user is moving the handheld. (1)

**R[6]** Pressing the buttons on the handheld will invoke the proper response on the computer. (1)

### 3.3 Environmental Requirements

This section will describe the environmental requirements the assembly products must comply, and the operation conditions of the system.

**R[7]** The prototype will operate at 5℃ to 35℃. (1)

**R[8]** The prototype will operate between a humidty range of 10% to 80%. (1)

**R[9]** The system shall conform to the directive set by RoHS. (3)

**R[10]** The systems circuit board will withstand temperatures used in the assembly process. (3)

### 3.4 Safety, Regulations, and Energy Efficiency Requirements

**R[11]** The prototype will be powered by an existing source of energy. (2)

**R[12]** The web camera will be powered through the computer's USB port. (1)

 

**R[13]** The device and its related components must not have sharp corners or edges that may harm the user. (1)

**R[14]** All wires must be contained within the device enclosure and properly connected. (3)

**R[15]** The device must meet IEC 60601-1-2 Electromagnetic Requirements; Radiation (EMI) and Immunity (EMS) standards. (3)

**R[16]** The device must meet standards with limits for Class A digital devices for usage in commercial, industrial or business environments. (3)

**R[17]** The device must meet standards with limits for Class B digital devices for usage in residential environments. (3)

**R[18]** The device must comply with Part 15 of the FCC Rules. (3)

**R[19]** The system shall conform to the requirements for UL, CSA and CE for domestic use. (3)

### 3.5 Reliability Requirements

**R[20]** The onscreen cursor must be at the exact location of where the user is pointing. (1)

**R[21]** The mouse clicking function must be duplicated every time when the user presses the handheld button. (1)

**R[22]** If the reference markers on the handheld stray out of the web camera's field of view, re-entering into the field should yield the same accuracy for the cursor location. (1)

**R[23]** After calibration, the accuracy must be held constant (i.e. no drifting). (3)

### 3.6 Overall Test Requirements

**R[24]** The cursor must follow the direction of the handheld device at all times when moved vigorously. (1)

**R[25]** The tracking system must still remain accurate even after having the reference markers leave and re-enter the web camera's field of view. (1)

 

**R[26]** The system must respond appropriately when any of the mouse buttons are pressed. (3)

# *4. Interface Requirements*

This section describes the various interfaces that are available for user interaction. This includes user input and computer feedback.

### 4.1. User and Handheld Device Interface

**R[27]** There shall be a on/off switch on the handheld device. (3)

**R[28]** There shall be a right click button. (1)

**R[29]** There shall be a left click button. (1)

**R[30]** There shall be a wheel mouse. (3)

**R[31]** There shall be a off button to terminate the software. (3)

### 4.2. User and Software Interface

**R[32]** There shall be executable action to initiate the tracking program. (3)

# *5. Handheld Remote Subsystem*

The handheld remote subsystem is a portable device which is responsible for sending the user's input to the web camera subsystem.

### 5.1. General

**R[33]** The subsystem will be light weight. (3)

**R[34]** The subsystem must be portable. (1)

**R[35]** The subsystem must contain buttons. (1)

**R[36]** The subsystem must contain reference markers. (1)

 

### 5.2. Physical Requirements

**R[37]** The handheld subsystem will have a weight of less than 100 grams. (3)

**R[38]** The handheld remote subsystem must have a dimension of less than 120mm x 40mm x 20mm. (3)

### 5.3. Communications Requirements

**R[39]** The handheld remote subsystem shall allow the user to input information to the web camera subsystem using reference markers. (1)

### 5.4 Power Requirements

**R[40]** The handheld remote must be rechargeable battery powered. (1)

**R[41]** The handheld remote will have a minimum recharge life of one month. (2)

### 5.5 Testing Requirements

**R[42]** The handheld remote reference LED markers must be placed in specific positions to ensure accurate readings. (1)

## *6. Software Subsystem*

The Software subsystem will be responsible for calculating and tracking the motion based on the input captured from the web camera and handheld remote.

### 6.1 General Requirements

**R[43]** The software must be compatible with Windows XP, and NT-based platforms. (3)

### 6.2 Communication Requirements

**R[44]** The subsystem must be able to communicate with all USB web cameras through OpenCV. (1)

 

**R[45]** The subsystem will control the mouse cursor through OpenCV. (1)

### 6.3 Testing Requirements

**R[46]** The subsystem must track the input to the web camera efficiently and control the mouse movement smoothly without taking excessive processing resources of the computer. (3)

# *7. Web Camera Subsystem*

The Web Camera Subsystem will be responsible for taking the input of the handheld device and communicating with the Software subsystem.

### 7.1 General Requirements

**R[47]** The web camera must be connected to the computer via a USB port. (1)

### 7.2 Physical Requirements

**R[48]** The web camera must be placed directly above the monitor screen to capture images of the handheld device. (2)

**R[49]** The web camera must be USB 1.1 compatible. (1)

### 7.3 Communication Requirements

**R[50]** The web camera must communicate through the USB. (1)

**R[51]** The web camera must have a field of view wide enough to receive the input of the handheld device without distortion. (2)

**R[52]** The web camera will be controlled through OpenCV. (1)

**R[53]** The subsystem will be operating with a minimum frame rate of 30 fps to ensure smooth and accurate motion capture. (2)

 

## *Documentation and User Training*

The SmartPoint device targets consumer market for ages 5 and above. We aim to provide a very simple and intuitive set of instructions so the user can operate

the device with minimal training. The following list provides a set of criteria for documentation and user training.

**R[54]** The user manual will be provided in English, Traditional and Simplified Chinese, Japanese, Korean, French, German and Spanish. (3)

**R[55]** The setup instructions will be clear and intuitive to suit users of all levels of electronics and computer knowledge. (3)

**R[56]** The users should be able to operate SmartPoint with minimal training. (3)

**R[57]** The user documentation will provide all the information regarding the safety, capabilities, and specifications of our device. (3)

**R[58]** Contact information to reach service staffs will be available for additional help on operating the SmartPoint device. (3)

## *Device Limitations*

The SmartPoint device utilizes the web camera as an input to control the mouse cursor on the screen. A limitation to this design would be the field of view of the web camera. For our prototype, we may operate our device based on a specific web camera field of view. For future modifications, we will consider implementing our program to adjust to work with all web cameras with different field of views. Another limitation would be potential IR interference or the lack of light source for the web camera due to the surrounding environment when operating the SmartPoint device. Finally, the accuracy and smoothness of the motion capture relies heavily on the capability of the web camera and the processing power of the user's PC.

# *8. Conclusion*

This document includes all the functional specifications of the three subsystems that are in the SmartPoint device. The details listed are all that are required to successfully complete and test the construction and operation of the SmartPoint. By April 2007, the SmartPoint will be completed to meet all the specifications listed in this document.

 