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June 25, 2001

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
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Re: ENSC 340 Functional Specification: Dancing Orpheus Musical Suit

Dear Dr. Rawicz,

The attached document, *Functional Specification: Dancing Orpheus Musical Suit*, details the functional specifications of our project for ENSC 340.

The purpose of this document is to detail the various system and interface requirements as well as the test methods that would be applied to our prototype to verify its functionality. Within the specification, some requirements are indicated as basic features that must be completed for the project deadline in August, whereas the enhancement features will be added only if time is available.

MiNT consists of five innovative third year engineering students – Sharon Chang, Eddy Chiu, Tony Leung, Robert Sin, and Lydia Tse. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (604) 420-3628 or by email.

Sincerely,

Eddy Chiu
MiNT, Inc.

Enclosure: *Functional Specification: Dancing Orpheus Musical Suit*

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Functional Specification: Dancing Orpheus Musical Suit

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Submitted to:

Dr. Andrew Rawicz – ENSC 340
Steve Whitmore – ENSC 305
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Executive Summary

Advancements in technology have been an important factor in revolutionizing art and entertainment. With the introduction of the *Dancing Musical Suit*, which allows a dancer to play music at the same time, composing music will become easier and more fun than ever.

The basic operations of the *Dancing Orpheus Musical Suit* include tracking a dancer's motions and generating sequences of musical notes. In addition, the user can also vary these notes by changing the pitch or generating flats and sharps. The prototype is designed to output to a low power speaker or an amplifier. If this is available, various enhancement features such as sound effects and computer interface will be added.

The development of this project spans a 13-week period, with August 24, 2001 being the scheduled completion date for a working prototype.

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1. Introduction

The *Dancing Orpheus Musical Suit* is a device that generates music based on a dancer's motions. The device consists of eleven motion detectors and a sound generation unit. All musical notes at a wide range of pitches are featured by the *Dancing Orpheus*, allowing it to compose music at the same level of complexity as any other sophisticated musical instrument. The main objective for this project is to complete the assembly of a functioning device by August 2001.

1.1. Scope

This document describes the basic functional requirements for the *Dancing Orpheus Musical Suit* as well as various enhancement features that would be implemented on the system prototype if time is available.

1.2. Reference Specification

1.2.1. Applicable Documents

[1] Engineering Science Communications Handbook 7th Edition, S. Stevenson, S. Whitmore, 1999.

[2] An Introduction to Low Power Radio, P. Bernie, J. Fairall, 1998.

1.2.2. Reference Documents

[1] *Proposal for the Dancing Orpheus Musical Suit*, S. Chang, E. Chiu, T. Leung, R. Sin, L. Tse, 2001.

1.3. Objectives

The following notations are used throughout this document:

[R#] A functional requirement.

(n) The priority of the requirement.

(1) Basic functional requirement.
(2) Enhancement feature.

2. System Requirements

2.1. System Overview

Figure 1 shows the system overview of the *Dancing Orpheus Musical Suit*.

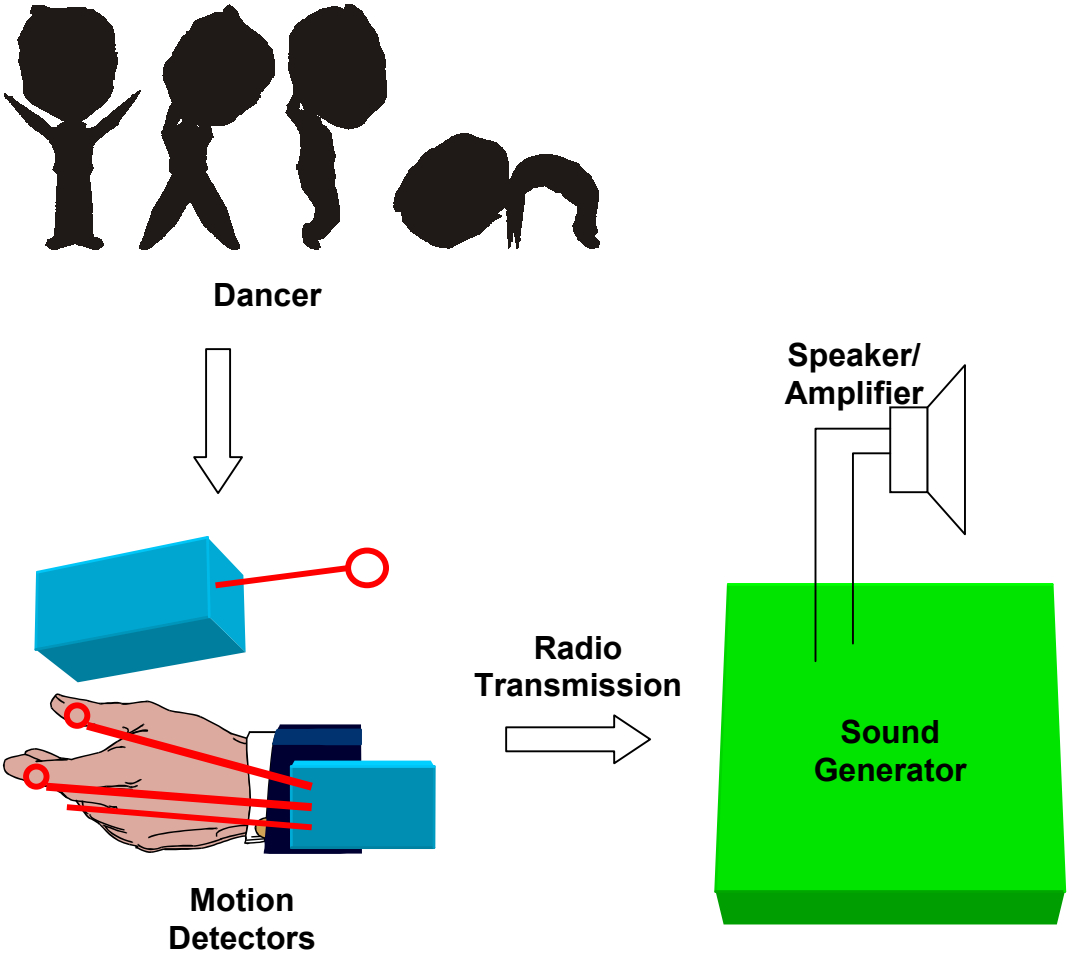

Figure 1: System Overview

The device tracks a dancer's motions and sends the data to a detached sound generator through pairs of radio transmitter and receiver.

The motion sensors are to be worn at the major body joints, each of which controls the playing of a predefined musical note. The placement of the sensors is shown in Figure 2[1].

[1] Refer to **[R8]** and **[R9]** for further information on sensor placements.

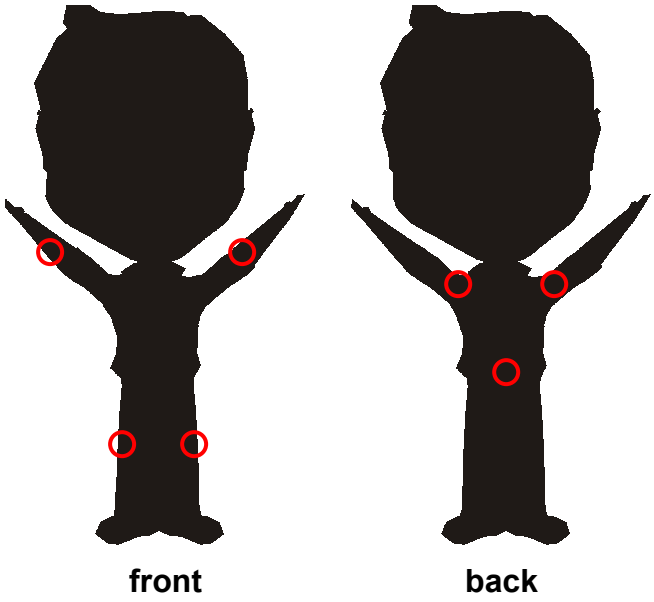

Figure 2: Sensor placement

When the sensors detect an angular movement beyond a preset threshold value, an activation signal will be generated, which causes the sound generator to produce the digitally synthesized tone.

The *Dancing Orpheus* is designed mainly for user entertainment. However, with further developments it may become an instrument for physical therapy. Playing music with the *Dancing Orpheus* is a healthy exercise. Songs that involve varying degrees of movement and flexibility may be designed to test the patients' recovery progress.

2.2. Physical and Environmental Requirements

[R1] (1) Each motion detector would not interfere with the user's motion. The prototype is expected to reside within a case with dimensions of (approximately) 5cm long, 5cm wide and 3cm high. Further development with more advanced equipment and circuit layout techniques would reduce the size by up to 50%.

[R2] (1) The sound generator would be portable and would be able to reside within a case with dimensions of (approximately) 10cm long, 10 cm wide, and 5cm high.

[R3] (1) The device would be able to operate at the range of temperature from 30^0c to 40^0c, around the body temperature.

[R4] (1) The 11 motion detectors would not burden the user and would weigh less than 2kg altogether.

[R5] (1) The sound generator and a low power speaker together would weigh less than 5kg.

[R6] (1) The case of the motion detector would reside within a water-proof case (made of a polymeric material) which protects the internal circuitry from sweat and other moistures.

[R7] (1) The motion detector would be able to operate under vibration – from the dancer's motion.

2.3. System Requirements

2.3.1. General

[R8] (1) 11 motion detectors:
- i) 7 control the generation of the notes
- ii) 2 control the raising and lowering pitch
- iii) 2 control the generation of flats and sharps

[R9] (1) Note generation detectors are distributed:
- i) 2 at the elbows
- ii) 2 at the knees
- iii) 2 at the shoulders
- iv) 1 at the back of the hip

[R10] (1) Pitch controlling detectors are worn at the back of the left forearm.

[R11] (1) Flat and sharp generation detectors to be worn at the back of the right forearm.

[R12] (2) Effect generation detectors are distributed:
- i) 2 at the ankles
- ii) 2 at the wrists
- iii) 1 at the back of the neck

[R13] (1) The transmission range from the motion detector to the sound generator would reach 50m. This is the range of transmission provided by common commercially available transmitters.

[R14] (1) The sound generator outputs frequencies from 60Hz to 8000Hz (same frequency range as common computer speakers).

[R15] (1) Each note turns off after playing for 2 seconds.

[R16] (2) The sound generator would mimic the sounds of various musical instruments.

[R17] (2) The sound generator would incorporate various sound effects that are controlled by additional motion sensors.

[R18] (2) The sound generator would record and play back a finite sequence of notes.

[R19] (2) The sound generator would interface with a host computer for motion capturing.

2.3.2. Power Supply

In order to achieve portability, *Dancing Orpheus* will be designed to operate under low power and run on batteries.

[R20] (1) The motion detectors would operate on 2 button cell batteries that provide up to a total of 6V DC.

[R21] (1) The sound generator would operate on a single 9V battery.

[R22] (2) The device would have rechargeable power supplies.

2.3.3. Sound Quality and Effects

[R23] (1) The sound generator would generate a bandwidth of 7 pitches of musical notes.

[R24] (1) The sound generator would have sound quality similar to MIDI sound files.

[R25] (2) The sound generator would incorporate sound effects such as adding echo, base and beats.

2.3.4. Compatibility

The *Dancing Orpheus* will interact with existing audio products. If a computer interface is developed, it must conform to the corresponding data communication standards.

[R26] (1) The sound generator would be compatible with any common low power speaker.

[R27] (1) The sound generator would be compatible with any common audio amplifier.

[R28] (2) The sound generator would be able to interface with a host computer through an ISA connection.

2.4. Reliability and Serviceability

[R29] (1) The *Dancing Orpheus* must operate for reasonably long periods of time – up to 24 hours – without failing.

[R30] (1) The motion detectors should withstand continual vibrations from the user's movements.

[R31] (1) The motion sensors operate completely independently of one another. Therefore, the systems would continue to function if any single part fails.

[R32] (2) New sound effects can be downloaded onto the sound generator with a host computer.

2.5. Modes of Operation

[R33] (2) The sound generator would have a record mode.

[R34] (2) The sound generator would have a playback mode.

2.6. System Limitations

[R35] (1) If the user attempts to play more than one note, the one with the lower frequency will be generated.

3. Interface Requirements

3.1. Motion Detector User Interface

[R36] (1) Each note generation detector connects between two muscle groups attached to a joint. When the muscles move away from one another, a wire is pulled or released, which generates a corresponding analog voltage.

[R37] (1) The pitch controlling detectors are positioned at the tips of the left index and middle fingers and are activated when they come in contact with the connector at the tip of the thumb.

[R38] (1) The flat and sharp detectors are positioned at the tips of the right index and middle fingers and are activated when they come in contact with the connector at the tip of the thumb.

[R39] (1) The elbows sensors are activated by linear flexion and turned off by linear extension.

[R40] (1) The knee sensors are activated by linear flexion and turned off by linear extension.

[R41] (1) The shoulder sensors are activated by raising the arm and turned off by returning the arm to the natural position.

[R42] (1) The hip sensor is activated by twisting the waist (**in any aesthetic way**) and is turned off by returning to the natural position.

3.2. Sound Generator User Interface

[R43] (2) If note and motion detector assignment becomes configurable, it would be controlled by a set of DIP switches.

3.3. Motion Detector Sound Generator Interface

[R44] (1) The motion detectors will transmit wireless signals to receiver at frequencies ranging from 300MHz to 400 MHz.

3.4. Sound Generator Speaker Connection Interface

[R45] (1) Regular headphone jack.

[R46] (2) A speaker output dedicated to sound effects.

[R47] (2) Stereo sound quality.

3.5. Sound Generator Computer Interface

[R48] (2) The sound generator would interface with a 32-pin ISA port.

4. Testing Methods

4.1. Motion Detector

[R49] (1) Activation and deactivation of each motion detector is verified using a logic analyzer.

[R50] (1) All motion detectors are activated simultaneously to verify effects of signal interference.

[R51] (1) Each motion detector would be tested on the angle extremity and force endurance.

[R52] (1) Each motion detector would be tested on the sensibility and the force endurance.

4.2. Sound Generator

[R53] (1) Each note will be played and verified using a logic analyzer.

[R54] (1) All notes will be played simultaneously to verify the ability of the device to resolve the output.

[R55] (1) Place the sound generator at 50m away from the dancer to verify data transmission at extreme distance.

5. Regulatory Standards

[R56] (1) Safety standards:

i) CSA C22.2 No 1010.1-92
ii) IEC 1010-1:1990 +A1:1992 +A2:1995
iii) UL 3111-1

[R57] (1) Wireless communication standards:

i) AR1B STD - T66
ii) IC RSS 139
iii) IC RSS 212
iv) IEC-60950
v) UL-1950

[R58] (1) Environmental standards:

i) HP Class C1 device.
ii) HP 757 – Temperature
iii) HP 758 – Humidity
iv) HP 759 – Vibration
v) HP 760 – Shock

6. Documentation and User Training

[R59] (2) Documentation of the *Dancing Orpheus* consists of a five page user manual with instructions in English, French, German, Japanese, Spanish, Chinese, and Korean.

[R60] (2) The user manual will be written for an audience with minimal experience with electronic device and music knowledge.

[R61] (2) The user manual will include a set of sample dance moves for two songs.

[R62] (2) The user manual includes a troubleshooting section.

[R63] (1) Minimal user training should be necessary for use of the *Dancing Orpheus*.

[R64] (1) Training of the device is completely provided by the user manual.

[R65] (2) The company web site provides a collection of dance steps for most popular songs.

7. Conclusion

This document has outlined the details of the functional requirements of the *Dancing Orpheus* project. By August 2001, all basic requirements denoted by (1) will be fulfilled, whereas enhancement features denoted by (2) will be added if time is available.