September 20, 2010

Mr. Mike Sodjerma
School of Engineering Science
Simon Fraser University
8888 University Drive, Burnaby, BC
V5A 16S

Re: Proposed Portable Music Recognition Device

Dear Mr. Sodjerma,

Please find enclosed Harmony Inc.'s proposed specification for a portable sheet music scanner. This device will be a prototype for a range of new handheld music recognition technologies.

The proposal will outline major milestones of the development cycle of the device, as well as its estimated commercial and educational values will be outlined briefly to summarize the potential of this technology.

The project team includes four fifth year students; Sean Edmond, Veronica Cojocaru, Nikola Cucuk and Cris Panaitiu. This highly dedicated project team has already begun work on the first prototype of this device, the Maestro, with the first tested prototype due by the middle of December 2010.

Please feel free to contact me with any questions you may have, either at my phone (778 320 5346) or by email (ensc440-2010@gmail.com).

Sincerely,

Cristian Panaitiu
Chief Executive Officer
Harmony Innovations Inc.

Enclosed: Proposal for "The Maestro" music education aid

2010

Project Proposal

The Maestro™

Portable Sheet Music Scanner and Player

A project commissioned by Harmony Innovation Inc.

MISSION STATEMENT

At Harmony Innovations, the future is our passion.

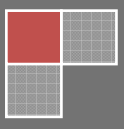
By combining musical education with the technological advances of today, Harmony Innovations strives not only to enhance the quality and accessibility of musical education for all students; but also to provide support and technology as a partner to many up and coming artists.

Technology has enormous potential to enhance our lives and this is the guiding principle behind Harmony's comprehensive approach to musical education.

Date Submitted: September 23rd, 2010

Submitted to:
Dr. Andrew Rawicz (ENSC 440)
Michael Sjoerdsma (ENSC 305)

Project Team:
Sean Edmond (301026670)
Nikola Cucuk (301033241)
Cris Panatiu (301032665)
Veronica Cojocaru (301055896)



Executive Summary

Music has always been one of the cornerstones of human civilization. Not just as a form of entertainment, but as a universal language to express what can be understood by everyone.

Harmony Innovations Inc. recognizes the importance of music and strives to create and develop new digital technologies to enhance the process of musical education.

Digital electronic solutions for the enhancement of the educational experience for up and coming artists is the guiding principle Harmony is based on and will help tomorrow's generation speak this universal language through helping with the most fundamental part of the learning process, practice.

Outlined in this document is the proposal for a music scanning , recognition and playback device that is intended to help new students with their musical studies by providing a simple example of the musical material. The twelve week design and testing process is outlined for the information of investors, as well as the commercial and educational opportunities of this device.

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1. Introduction

"Music education is the epitaph of human achievement and embodies the desire to understand that which we do not understand through that which we do" – Socrates

Throughout history, humanity has placed enormous value on the creation of music. The ancient Greeks, for example, believed that music is the "subtle, yet complete understanding of human nature and the human existence"; devoting much time to the study and composition of music. Like the Greeks, every civilization, ancient to contemporary has devoted enormous energies towards the development of music.

The effort to express through music is by no means exhausted today, especially with the advent of new technologies through which music can be more easily created. Musical education, however, has not benefited sufficiently from the progress made in digital music technologies; most learning is done through a process of demonstration and practice by a teacher and a student.

While a teacher should not be replaced, students can make their practice more efficient with the help of digital technology. Harmony Inc. is proud to be able to present a revolutionary new line of musical education aids.

2. System Overview

The Maestro will be comprised of 3 higher level components, illustrated in Figure 1. Firstly, some device will be used to acquire an image of the sheet music. Then this image will undergo processing to recognize the pitch and rhythm of the music. Lastly, the interpreted music will be played through some audio interface.

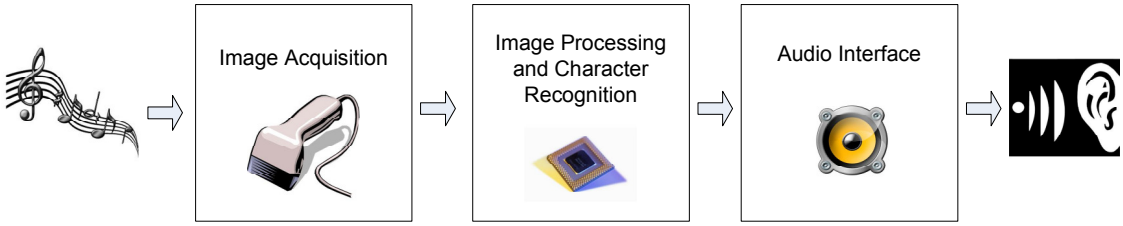

Figure 1 - System Block Diagram

3. Existing Design Solution

In investigating design solutions we reflected on our personal experiences as well as doing market research at Tom Lee. This has provided us with some valuable information about the market of music notation learning aids. Novice musicians can employ a variety of methods to convert sheet music to audible sound when learning music. These existing solutions are all not convenient or intuitive to use, preventing them from being used frequently and being integrated into your practice sessions.

3.1 Market Research Investigation

To investigate our market we decided to visit music stores to talk to the sales associates.

We first asked them what products were available to help musician learn by ear. The sheet music department sold a software package called Finale. This software allows you to write music quickly with a user interface. It can then covert you written music into MIDI format. However, the process of entering in the music with this user interface is time consuming. They also mentioned that many music books are being published with specially design lessons to help musicians learn by ear.

We also asked how many musicians purchase an electronic device (such as a tuner) when they buy an instrument. They said the majority of stringed instruments purchase an electronic tuner. The electronics department mentioned that home recording systems have taken off in the last decade.

When asking them about our product we got a positive response from both departments. They said novice musicians are always looking for an easy way to learn how to read music (and most would rather skip this step in the first place). The electronics department mentioned that there is some software that can take an image from a flat-bed scanner and convert to MIDI. However, he said there is no product like ours that is stand-alone and can operate in real time. The electronics department also mentioned that MIDI format has become the industry standard in all electronic music devices and that there is even software that can covert sound to MIDI.

3.2 Hearing Other Musicians Play

The simplest way to convert sheet music into sound is to have an experienced musician play it to you. Needless to say, an experienced musician will not be available all the times that you want to hear a particular piece of music. Taking music lessons is a good way to interact with expert musicians, but it is expensive and the musician still won't be available when you practice and need to hear what a particular piece of music sounds like.

3.3 Music Recordings Included With Sheet Music

Some instructional books on the market contain CDs with recordings of the songs or exercises in the book. This solution is very restrictive since you only have access to the music that is already recorded on the CD. This doesn't help you if you want to learn a particular piece that is not in the book, or if you want to hear the music in a different tempo.

3.4 Software that Converts Sheet Music to Audio

Using software to convert sheet music into playable sound files is not a convenient solution. You need to have a computer available at the exact time that you want to hear what the sheet music sounds like. If the sheet music that you want converted isn't already on the computer, then you also require a scanner to scan it and then convert it to an acceptable format, like PDF. Most scanners are not very good at scanning pages from a book and it takes some trial and error to do so. Because this takes a lot of steps to go from sheet music in a book or on paper to audio, it is very cumbersome and not something that you would want to do in the middle of a practice session.

4. Proposed Design Solution

4.1 Image Acquisition

Image acquisition or notes scanning will be done using a visual sensor. This sensor will capture black and white images with a high frequency similar to a camera. These images are sent to another the digital processing unit block or the micro-controller using the USB interface. These images will get compared and processed in the micro-controller such that MAESTRO™ can extract the music from the music staff paper. Image acquisition, will get initiated using a button and the user will need to move the scanner in a consistent motion over the music staff paper. There are several proposed solutions for this module ranging from a 2D bar code reader, infrared camera and black and white CCD camera. This block is work in progress and further research is essential.

4.2 Image Processing and Character Recognition

Once the image has been scanned and pre-processed, the OCR (optical character recognition) software will take over and convert the image into MIDI. For the OCR software we can either use already existing open-source image recognition software or we can write our own custom software. The advantages of using the open-source software is that it is already existing and will probably be easy to adapt to our particular tasks, however the disadvantage is that in order to run it we would need a powerful processor and it will need to run an operating system. Running an operating system will be a big challenge and we are unsure that it is the best way to proceed. It is likely that writing our own image recognition software will be the more time-efficient.
Converting the sheet music into MIDI is the intuitive thing to do since MIDI is a representation of a note's pitch, duration, etc, exactly what we want to encode. The challenge then comes with converting the MIDI into audio via our player. For this we will require a sound card that supports MIDI and we will need to design an interface.

4.2 Audio Interface

The audio interface will be the component that interprets the midi packets and transforms them into wave files. The interface will comprise of a standard midi packet receiving interface. This will receive midi packets through the input ports and create a digital wave output. This output will be available digitally for the user, and it will be stored in the internal memory of the device or optionally stored on the user's computer through a USB connection. Sound will be produced based on standard midi decoding firmware.

5. Sources of Information

For the duration of our research we have used several sources to expand on our understanding of the portable sheet music scanner and player (MAESTRO™). While researching the music market and MAESTRO™s design concepts we turned ourselves to professors, musicians, potential consumers, group members, journals and course textbooks. Brief meetings where held with Lesley Shannon, Lakshman (Lucky) and Ivan Bajic. For example, we consulted Ivan Bajic regarding image acquisition and processing. Next, we consulted and interviewed musicians. For instance, our group member Sean Edmond interviewed novice musicians about our product and if our proposed solution might help them get trained in music better. Some undergraduate students in Engineering Science have previously worked music projects and where contacted for technical information and suggestions. Finally, the most important source of information where individual group members who helped shape MAESTRO™ . Some group members where novice musicians and remember troubles learning music the traditional way by reading complex notes. This is how a problem of reading notes turned into a proposed product for scanning and playing music. Furthermore, Internet is a great way of quickly searching and accessing digital sources. We used internet to retrieve information related to funding, similar projects, and other technical information. For example, while searching for similar projects we got new ideas and features that we implemented in our product MAESTRO. Although, we where unable to find a similar products online, we managed to better define our product such that we narrow the gap between musicians and music learning. Finally, for design and parts selection, we tuck advantage of published electronic journals and course text books. Some courses used in the past will help us with our product design and module integration. We are thinking of using C or C++ to write drivers which integrate between different project modules such as image acquisition and digital processing block.

6. Budget and Finances

6.1. Budget

The table below indicates the estimated budget for MAESTRO™. As the details of the device are still tentative, the prices presented in the table are not precise. In order to keep the table brief, the components have been grouped into categories that represent their general functional group. Moreover, the approximated budget does not include any development or manufacturing costs.

Equipment List	Estimated Cost
Microcontroller & EVBD	$250
Speaker and audio module	$105
Camera	$120
Microcontroller programmer	$75
Electronics	$100
Contingency Fund	$150
Total Cost	**$800**

6.2. Funding

MAESTROs™ budget for this production prototype is limited. Different sources of funding are being considered to raise money for its high price. The cost of developing the first prototype is much higher than the price of a mass produced unit. Therefore, the above estimated table 1 does not reflect the final production costs accurately. Due to the high cost of this project, many sources of funding are being considered. A potential source is the Engineering Science Student Endowment Fund for which an application was already submitted. We are also considering approaching Dr. Bozena Kaminska for financial donations. Financial transactions and receipts will be kept to ensure proper reimbursement to the members of the group if funding is approved. We are planning to introduce and develop this product to the market after completion. We believe that this product has a well defined market and that this music learning solution is catchy and has a potential to grow.

7. Schedule

A visual representation of our project schedule is shown in by the Gantt Chart in Figure 2. This chart illustrates the expect amount of time to complete each task, a the interdependencies between task (such as integration). Important project deadlines and deliverables are outline in Figure 3.

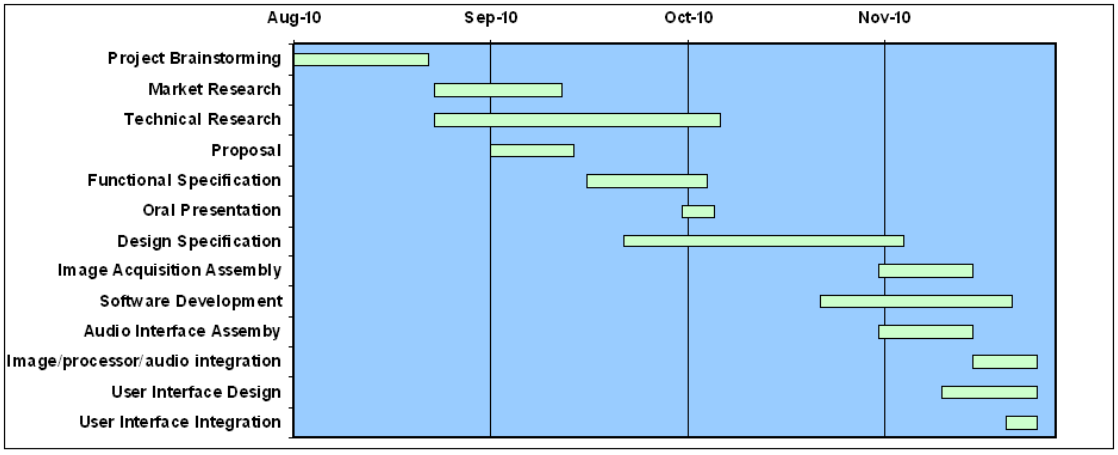

Figure 2 - Project Schedule

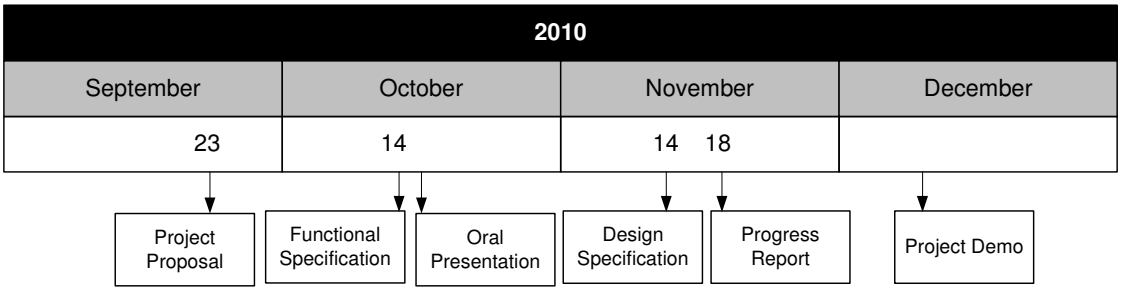

Figure 3 - Project Deliverables

8. Team Organization

Part of Harmony's approach to high tech design comes from understanding how the dynamics of a development platform function at the optimum level.

The concentration of tasks into grouped deliverables allows for efficient management of tasks and creates an optimized environment in which project goals are easily identified and scheduled.

Currently, the Maestro™ Project involves three of Harmony's distinct research teams; with researchers coming from Image Acquisition, Processing and Audio Interface Research. The progress of the project is continuously monitored and optimizations are made to ensure maximum turnover of milestones, while maintaining strict quality control criteria.

In its final stages of development, researchers from the Harmony's Integrated Control Circuits and Realtime Motion Sensing teams will collaborate on the project, implementing a motion control solution to the Maestro before integration and final testing will take place.

The Image Acquisition Team (I-ACT)

I-ACT researches new methodologies of sensing and capturing real-time images at resolution and quality that can be used as raw data for the higher stages of processing. The engineers in I-ACT come from a variety of backgrounds including optics engineering and CCD Tech.

Image data storage and retrieval is also the responsibility of I-ACT, with a part of the team concentrated on rapid buffering technologies (RBTs) and rapid bus technologies (RBuTs) that will allow for sufficiently rapid data capture and storage rates (SRDCASRs, or RDC, for short).

The Image Recognition Team (I-RET)

I-RET focuses on designing algorithms for the translation of digitized data for translation into acceptable digital formats. The team consists of algorithm design, implementation and optimization crews that are focused on developing and optimizing Harmony's proprietary InSound™®© ☺ algorithm for different applications within the music industry. The capabilities of this powerful algorithm will be fully exploited as a class II digital data recognition algorithm (see glossary) by I-RET).

I-RET currently comprises of talented individuals from diverse fields in mathematical modeling, data parsing, recognition and algorithm design. InSound™®© ☺ is the result of collaboration between I-RET and Matlab Corporation, as part of a multi-million dollar deal to research OCR software.

The Audio Interface Team (I-AIT)

I-AIT focuses on designing audio solutions for the implementation of real-time audio for the Maestro ™ Project. Comprised mainly of audio engineers and software developers, I-AIT is working on development of compact algorithms for the digital storage of music, as well as designing new codecs for decoding digital music data.

The Motion Team (I-MOT)

I-MOT focuses on the research and implementation of Harmony's revolutionary motion sensing technologies for the correction of analog imperfections, data correction, as well as the correction of image acquisition errors.

Comprising members from electronics and automation

9. Company Profile

Harmony Innovations was founded in mid-2010 by an enterprising team of engineers with experience in music theory and digital design. These engineers come from different background, but they share a common passion to improve musical education through comprehensive technological solutions. This common goal of combining technology with music to improve education has been the guiding principle behind both Harmony Innovations Inc.'s mission statement and modus operandi.

EXECUTIVE TEAM

Cris Panaitiu: Chief Executive Officer (CEO)

Cris is not your run of the mill CEO. He takes a different approach to technology because he doesn't see it as a hidden and scary part of our world. To Cris, technology is a natural extension of the real world with limitless possibilities to improve and augment.

Cris boasts an impressive technical resume which spans automation, industrial control, infrastructure design, as well as programming. On the musical side, Cris is currently completing the royal conservatory of music program and has taught music to students of his own. Far from being a distant member of the executive team that acts important, Cris will be getting his hands dirty as part of the programming team. He will be putting his embedded programming skills to work integrating the audio component into the project. Technology isn't everything, however, and Cris has the whole package; having taught music to young students. The approach he takes to education, in which he involves the child's own creativity and encouraging individual exercise has inspired him to pursue and be fully involved in the Maestro™ Project.

In his spare time he is no couch potato either, pursuing a music education degree among other things. He particularly enjoys playing the piano, but has found the lack of a personalized example frustrating during his studies. His professor, the world renowned Ludwig von Beethoven once said that only through repeated examples can you form a musical intelligence; not from reading the scores.

Sean Edmond – Chief Technical Officer (CTO)

I am currently a 5th year electronics engineering student at SFU and nearing graduation. Throughout my degree I have focused particularly on digital system design. In summer 2008 I completed a research term under the supervision of Lesley Shannon that investigated the use of a hardware based processor profiler to assist system scheduling on heterogeneous multi core chip architectures. In summer 2010 I completed a research term enhancing the FPGA design

(hardware and software) of Arachnobot, a hexapod robot designed to scale difficult terrain, including vertical surfaces. However my experience has not just been limited to the SFU research lab. I have completed two 8 month coop semesters at MDA and PMC-Sierra where I was doing software development and Verification Engineering respectively. All eduation and work experience has led to confidence in my technical ability, and my industry experience has given me the discipline of proper project management. I also play the violin and have passion for music which provides unique perspective in designing products at Harmony Innovations Inc.

Nikola Cucuk – Chief Finance Officer (CFO)

Is a Forth year Electronics Engineering student at Simon Fraser University with previous co-op term experience at PMC-Sierra. He has outstanding organization and team management skills. In his previous jobs he was in charge of data reports generation and analysis. He reported regularly to his superiors and managed a chip performance verification team in India. His background is mostly in ASIC hardware verification and design. Although, his experiences have been mostly technical they helped him improve on project management, communication, and people skills. He is proficient in several programming and hardware design languages such as: C/C++, C#, Python, Matlab, Tck, Perl, Visual Basic, Assembly, verilog and VHDL. With his extensive background in programming, he will ensure smooth integration between the hardware and software aspects of the project.

Veronica Cojocaru - Vice President of Operations (VP Operations)

I am a fourth year Electronics Engineering Science student at Simon Fraser University with a varied skill-set and previous co-op workterm experience at Icron, PMC-Sierra, and within the university (doing research). I have programming experience in C, C++ and assembly language, particularly in designing and testing firmware for embedded systems as well as writing software user applications. I have experience with using common lab equipment as well as performing design, layout and testing of PCBs. I am familiar with using VHDL to design and specify custom circuits. I am a critical thinker and have strong organizational skills.

10. Conclusion

Harmony Innovation Inc. is on a mission to provide an easy-to-use solution to help student musicians learn by converting sheet music to audio. Our team of dedicated engineers and musicians keep this goal in mind as we design and develop the MaestroTM, a portable sheet music scanner and player. We know that learning sheet music is one of the hardest tasks facing a novice musician and our solution seeks to simplify this task with the help of an intuitive and affordable device.

Unlike the other solutions currently available, the MaestroTM is portable and convenient: no need to use a computer, no time struggle when getting a regular scanner to work, and most importantly no restrictions on when or where you can use it. Our system is a better learning tool than what is currently on the market because it is a device that a musician can easily integrate in their practice sessions and carry it with them wherever they go.

We have thoroughly considered the schedule and finances for the project to ensure that it will be completed both on time and on budget. We have described our sources of information and we will be vigilant in making sure that our solution is ideal for the market that we are targeting. We have given an overview of how the solution will be achieved and the different components that will be integrated into our final product. The MaestroTM will provide student musicians with a very important tool to use in their learning journey.