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March 12th, 2009

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The attached document describes the design specification for *DreamBox* musical entertainment system from Mutrix Technology. We aim to design and implement an innovative musical ornament with potentials to be widely applied in various situations.

The design specification gives an informative system overview, system architecture and different design aspects of the project.

Mutrix Technology consists of five motivated, hard working, and talented fifth-year engineering students: Benson Lam, Gary Heng, Winfield Zhao, Shuozhi Yang and Weiguang Mou. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (604)537-9289 or by e-mail at mutrixtechnology@gmail.com.

Sincerely yours,

Benson Lam

President and CEO

Mutrix Technology

Enclosure: *Design Specification for DreamBox*

Post Mortem Report

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Date: 10/4/2009
Revision: 0.1

TABLE OF CONTENTS

List of Figures 2

List of Tables 2

1. Introduction 3

2. Current State of the System 3

3. Deviation of the System 5
   3.1 Motor Controller Power Source 5
   3.2 Crystal Bar Selection 6
   3.3 Selection of USB Connection 6
   3.4 Function Expansian 6

4. Future Plans 7
   4.1 Noise Reduction 7
   4.2 Packaging 7
   4.3 Signal Processing Algorithm 7
   4.4 Miniaturization 7
   4.5 Wireless Connection 7

5. Budget Summary 8

6. Personal Reflection and Feedback 9
   Benson Lam – Chief Executive Officer 9
   Shuozhi Yang – Chief Programming Officer 10
   Winfield Zhao – Chief Technical Officer 11
   Gary Heng – Chief Design Officer 12
   Weiguang Mou – Chief Financial Officer 13

7. Conclusion 14

LIST OF FIGURES

Figure 1: System Block Diagram 4

Figure 2: Conceptual and Actual Appearance of DreamBox 4

Figure 3: Computer User Interface 5

Figure 4: Motor Controller Configuration 6

LIST OF TABLES

Table 1: Budget Summary of *DreamBox* Development 8

1. INTRODUCTION

In the past thirteen weeks, Mutrix Technology development team has been working diligently hard on prototyping the conceptual model of *DreamBox*, an innovative digital musical entertainment system. This project aims to bring the users incredible visual experience while enjoying music. The entire system development is divided into four subsystem developments including computer GUI, mechanical hardware, on-board system and display effect design. Every team member is well involved in the system development and makes great contribute while learning and practicing new skills.

This document provides the audience a clear view of the outcome of the development, presents the current state of the system, and includes a personal reflection where personal experience and feedback during the development from each team member is described.

2. CURRENT STATE OF THE SYSTEM

As described in the project proposal, *DreamBox* works in either the dynamic mode or the static mode, in which it can perform as a dynamic musical statue or static artistic ornament, respectively. The user can switch *DreamBox* between the dynamic mode and the static mode by simply using the push button switches. The system consists of three major parts: Central Control Unit (CCU), Motor Mechanics System (MMS) and Software User Interface (SUI). The following system block diagram shows the overall design of *DreamBox* musical entertainment system.

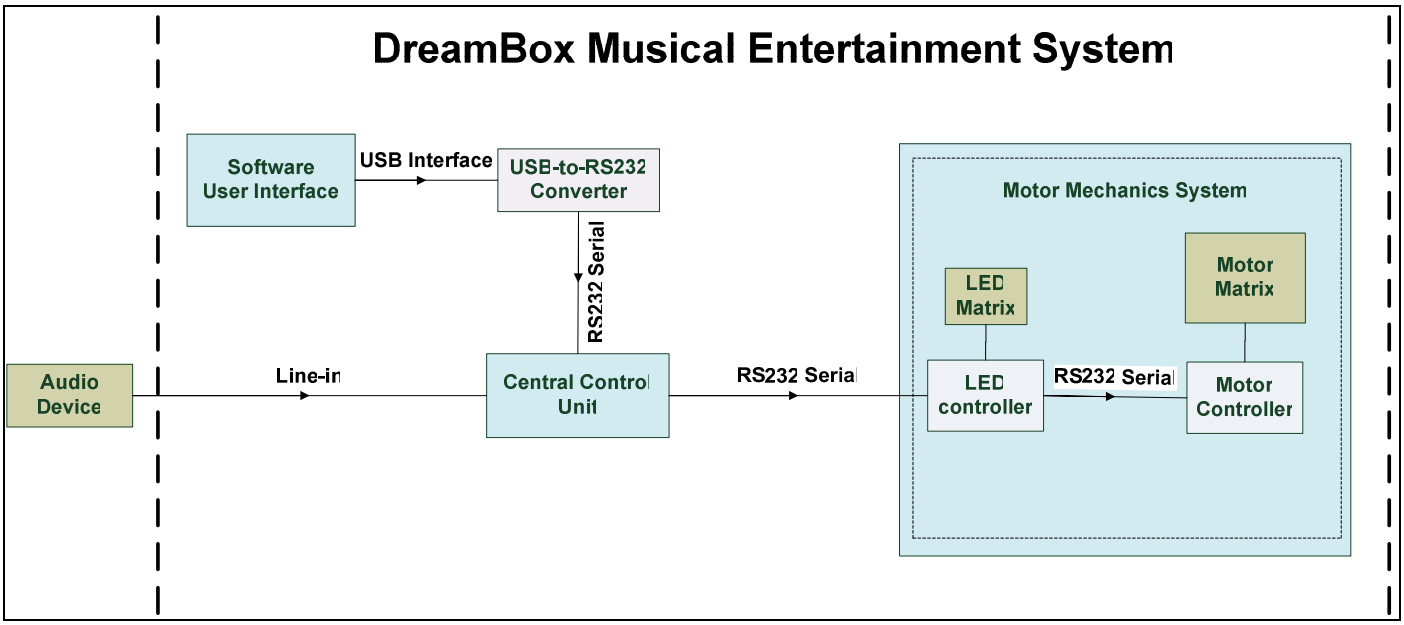

Figure 1: System Block Diagram

For the system appearance design, we use crystal bars to form a 5x5 square matrix. With the help of LED lighting effect, the appearance of the crystal bars can be shiny and clear. The following figure shows the conceptual and actual appearance of *DreamBox*.

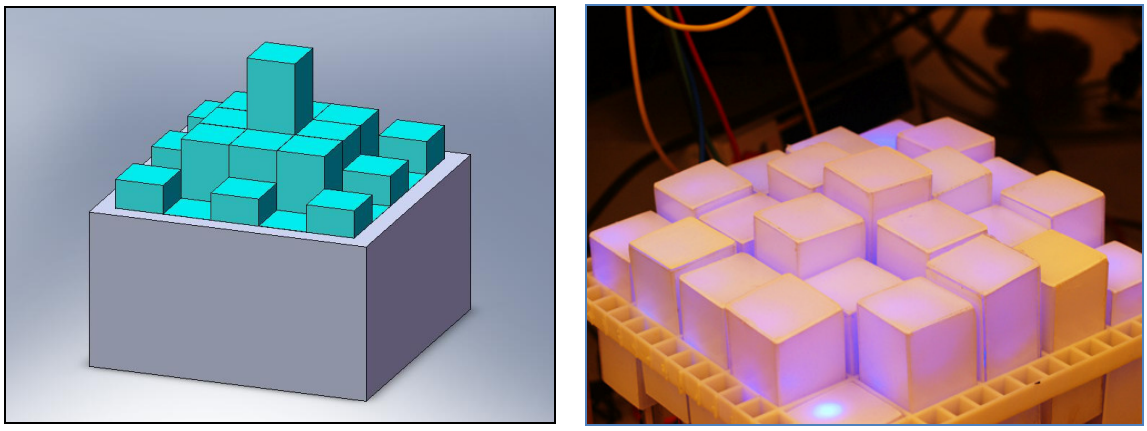

Figure 2: Conceptual and Actual Appearance of DreamBox

The performance of the music beat detection algorithm and system response is quite the same as what we expected in the proposal. Music beats are detected in real time fashion and reflected in the form of different patterns presented by the crystal bars.

Written in Visual C#, the user interface is a convenient platform that is well designed to reduce the complexity to configure the system. It is also capable of storing user-designed

configurations in local files as well as on-chip memory (EEPROM) so that the user can retrieve any user-designed pattern even without the access to computer. The following figure shows the finalized version of the GUI.

Figure 3: Computer User Interface

During the development of the system, we have constantly implemented tests over the system and computer user interface to avoid all potential errors or unhandled exceptional conditions.

3. DEVIATION OF THE SYSTEM

3.1 MOTOR CONTROLLER POWER SOURCE

One of the concerns during the development is the power supply for the motors that consume at most 200mA each. After several experiments, instead of using single power source to supply both the motors and the controller chip, two dedicated power sources and a 9-Volt battery are employed to supply the motors that are split into two sets and

the motor controller chip, respectively. Figure 3 shows the configuration of the motor controller.

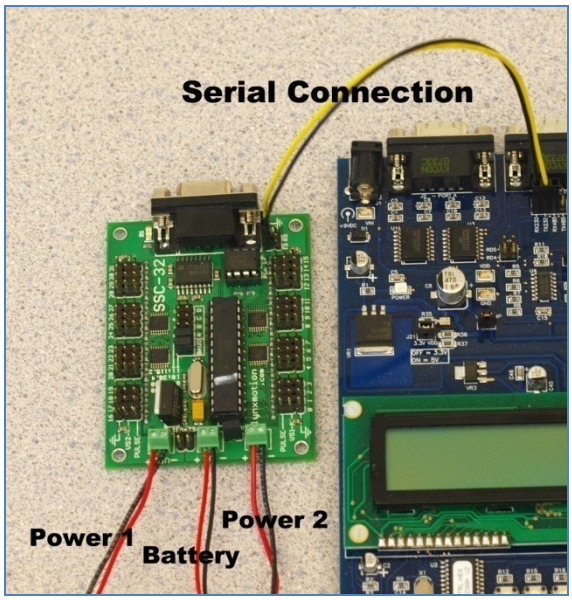

Figure 4: Motor Controller Configuration

3.2 CRYSTAL BAR SELECTION

We proposed to use crystal bars to form the matrix; however, we experienced a really hard time to find ready-to-use crystal bars to fit our need. Furthermore, the weight of real crystal or glass is over the strength of the servo motors. Therefore, we eventually decided to make our own "crystal" bars using plastic sheets.

3.3 SELECTION OF USB CONNECTION

We initially proposed to utilize Bluetooth in *DreamBox* for communicating between the system and the computer; however, the cost and time constraint makes us to choose the more efficient USB connection.

3.4 FUNCTION EXPANSIAN

During the development, we have added more features to *DreamBox* according to the suggestions from potential users, such as adding on-board GUI and the capability of saving computer-designed static patterns to on-chip memory (EEPROM).

4. FUTURE PLANS

DreamBox is currently under research and prototyping period, issues are found during development and future improvement is essential to perfect the system:

4.1 NOISE REDUCTION

During the system operation, the motors' noise is unexpectedly loud, which may pitifully reduce the enjoyment brought by *DreamBox*. Currently, the motors are cased in a plastic cover that can compensate some of the noise in limited level. However, effective noise reduction system is definitely essential to make the system practical in daily entertainment.

4.2 PACKAGING

The system is all handmade without any protective or decorative packaging. Before releasing the product to the market, well designed and protective enclosure will be needed.

4.3 SIGNAL PROCESSING ALGORITHM

The audio signal processing algorithm in present can effectively detect the beats in the music, however, more sophisticated algorithm will be needed in the future to provide better accuracy and more functions, such as detecting series beats in different frequency bands.

4.4 MINIATURIZATION

As a home entertainment system, the prototype of the system is too big for a 5x5 matrix. The goal of the future development will include the miniaturization of the system, which enables us to built new system with higher crystal bar resolution, such as building 100x100 crystal bar matrix in acceptable space occupation.

4.5 WIRELESS CONNECTION

We plan to work on the Bluetooth connection for the communication between the system and the computer as proposed, which improves the ease of use and makes the system more convenient in terms of system placement arrangement at home.

5. BUDGET SUMMARY

The following table shows the budget summary of *DreamBox* project by Mutrix Technology development team.

Table 1: Budget Summary of *DreamBox* Development

	Proposed	Actual	Discrepancy
Microcontroller dev. Board	$300	$570	-$270
LED's	$20	$30	-$10
USB-to-Serial Adaptor	n/a	$20	-$20
Breadboard	n/a	$10	-$10
Servo Motors	$500	$160	$340
Gears	n/a	$80	-$80
Motor Controller	n/a	$66	-$66
Crystal Bars	$50	$50	$0
Power Amplifier	$200	$0	$200
Shift Register	n/a	$20	-$20
Circuit Components	$50	$0	$50
Cover	$100	$20	$80
Others	$50	$120	-$70
Total:	**$1270**	**$1146**	**$124**

The final cost is less than expected because of the use of motor controller instead of controlling the motors directly by the microcontroller development board, which saves us 200 dollars. And the selection of servo motor also reduces the expected cost by about 300 dollars. The total cost includes the expenses of replacing the broken components during the development and backup items.

The main cost is concentrated on microcontroller development board and servo motor set. Once *DreamBox* is finalized, the cost of manufacturing *DreamBox* can reduced by about 50%. When it enters mass production stage, the cost for each product can be acceptable.

6. PERSONAL REFLECTION AND FEEDBACK

BENSON LAM – CHIEF EXECUTIVE OFFICER

The experience of working on this project was fabulous due to healthy group dynamics. I found my colleagues in Mutrix Technology to be intelligent, responsible, knowledgeable, patient and humorous. As being the CEO of this group, my task was to assign task to each member and monitor the progress of the project to ensure it was not behind schedule. There was no internal conflict toward the completion of the project and we had the project completed earlier than we had expected due to good teamwork. Teamwork is the main key to the success of this project.

We held team meeting every week to exchange ideas since the first month of the semester for the purpose of ensuring all members in the team had the chance to express their thought and point of view. I found communication and respect are important roles in building healthy dynamics. A member may lose interest in the project if he or she is not on the same page as the other members or if that member has no chance to announce his or her ideas. We divided the team into three subgroups to make sure workload was shared equally and no repetitive work was done between members. Two members were allocated in both the hardware and mechanical subgroups, and the remaining member was allocated in the software subgroup. During the weekly meeting, members of each subgroup were responsible to give a brief speech about the progress of their development. Furthermore, weekly subgroup report was collected to keep a record of each single development stage in each subgroup. All team members made a lot of preparation for each weekly meeting and worked hard to keep the progress on track.

This project is the first project we actually built out something from scratch. From the brainstorm stage to the design stage and then to the development stage and finally to the completion of the project, we fully applied what we had learned in the past five years of university career and the skills we had acquired from industrial experience. In the technical scope, I was responsible for the development of the GUI and the design of the mechanical system. Due to the substantial programming involved in the project, my programming skill has improved drastically. Since our project is a fusion of hardware, software and mechanics, I have acquired hand-on experience with hardware and mechanical design as well.

DreamBox is successfully built and works as the way as expected. Some good features were pitifully discarded due to the time constraint. In this project, we also learned how to adapt to the tight timeline and make changes from the preliminary plan if necessary. I am truly thankful to all members for their hard work and I am looking forward working with them again.

SHUOZHI YANG – CHIEF PROGRAMMING OFFICER

Different from other course projects, it is the first time that we implement our own idea from scratch. Starting from the formation of the team till the conclusion of the project, we have gone through the entire development stages. I really admire the experience gained in this project.

Working as meeting organizer and project planner, I learned that in order to work efficiently, a team must be well organized and united. I believe that no one can put full effort to a project he does not like. Since the first day of the project, we held team meeting every week during the design phase, in which we had lot of idea exchange to ensure every team member is satisfied with the design. Also, we only discussed about the general expectation and base design of each component of the system. Because this system is to be designed by every one of us, during the development every developer may come up with new ideas to add onto the base design, no one should be constrained by a fixed design. In the implementation phase of the project, the meeting was scheduled upon request. The flexible schedule guarantees that every developer can concentrate on his work without unnecessary interrupt. However, weekly individual short work report was collected to keep track of the progress of the development. Through this project, our team members seem to be quite satisfied with the arrangement and work hard to keep the progress on track.

In the technical aspect, I am very happy to find that in practical system development process, all I learned in the university study and from the industrial working experience is well applied. During the development period, I was involved in analog signal preprocessing circuit design, analog-to-digital converter setup, microcontroller system design, GUI development and communication system development. Being involved in so many aspects of the project, I have enhanced my understanding and programming skills in microcontroller development. I also found that reading document and datasheet seemed to be one of the most important parts of the digital system design. Without a full understanding of the device I was working on, time could be easily wasted. Although

reading documents seems to be a boring process, it is actually the most efficient way to start.

Self time management and team time management is another important aspect of development team. Constrained by the limited amount of time in thirteen weeks, we have to adapt our design with the time. Some good ideas were pitifully discarded due to the time limit and left for the future, which is also a good lesson to teach us about measuring our capability.

Helping each other in a team and even across teams is the key to improve skills and to broaden experience. No one can be expert in every aspect; thus, asking for help and providing help are common in the research lab. By helping each other, we not only start to receive new knowledge and skills, but also have a good chance to get suggestions about our design and make necessary adjustment.

In terms of teamwork, I think everyone is very happy with the outcome of our efforts. Although our *DreamBox* needs future improvement, the result matches our expectation quite well. I do not regret working with my team members.

WINFIELD ZHAO – CHIEF TECHNICAL OFFICER

In this project, I had the chance to work on mechanical, hardware and software. This project had strengthened my technical skills in these three different areas: mechanical, hardware and software. In this project, our team of 5 people was divided into 3 subgroups such as mechanical and hardware group, center processor and software group, and software computer GUI group. Each group was responsible for each main subsection. I was the subgroup leader of the mechanical group. I was mainly responsible for the mechanical system and the control hardware for the LEDs and the motors for DreamBox. I was working closely together with WeiGuang to design and assembly the mechanical system. Beside of designing the mechanical system for DreamBox, I also designed the LED control circuit and chose the suitable hardware board for the motor control. Although I was in mechanical group, I also had chances to experience software programming. I had designed the basic functions to control the LED matrix and the software functions for UART communication.

During the project, I had learn how to manager the design process. For example, the design process of the mechanical system is an iterating process. Before the design of the

mechanical system had been finalized, the design had been changed couple time. I also had learned how to choose proper components and materials which are suitable for our project. For example, at the beginning of our project, the crystal bars were made of thick plastic glass. The crystal bars which were made of the thick plastic glass increased the load to the motor; therefore, the crystal bars affected the turning speed of the motor. At the end, we remade the crystal bars with thin plastic glass to have the desired speed of the crystal bars movement.

Without team dynamic, our team would not achieve success. I had learned the team management skills as a subgroup leader and individual member of the project team. To unite each team members, it is necessary to hold regular team meeting every week to discuss problem and letting others know the progress status of each subgroup. If one subgroup fell behind, the other subgroup would offer help. At the beginning of the project, each team member was assigned some tasks to do. However, at the end of the project, when the combination of each task was needed to form the whole project, I worked together with other team members most of the time. This team is the best team I had worked at. When I needed help, other team members were very willing to offer help. For example, after I found out the crystal bars which were made of the thick plastic glass were not suitable for the mechanical system. All the team members gathered together to remake the crystal bars within a day.

I had learned a lot from this project and enjoyed it very much. Doing this project will becomes the most valuable experience of my four year undergraduate study as an engineering student in Simon Fraser university.

GARY HENG – CHIEF DESIGN OFFICER

I have gained tremendous social and technical knowledge in the past four months. It was my first time to build a product from design to finish. Working primarily on software algorithm and implementation, I am responsible for beat detection and pattern design. I did most of my research on the audio processing algorithms and it is very rewarding to find an algorithm that fits our specific application. I worked with Yang and Winfield most of the time as we collaborate on the lower level system design.

As a team, we constantly give help to each other, complementing one and another. The integration process is nearly effortless. This is because we keep on having one copy of the master code and everyone would add their code to it. Also, the fact that we are involved

in each other's role, there is always two people working on the same task. Time management is not an issue to us. In the previous semester, we had occasional meetings and decided to take similar courses so that we can all work on the project during class break.

There was one point where everyone was worried about the project. When it is close to the semester end and we had a few motors and LEDs broken. Since these components are essential in our project, we had to replace them. Conventional mail usually takes 2 to 3 weeks and we didn't have so much time. Gladly, we found an alternative route by driving to the United States to pick up the necessary items. When there is different opinion about the design, we would sit down and vote for the best solution. This is only possible in a group size of 5.

I like to work with my team members and am very proud of the accomplishment we have achieved. This project is stunning and we are going to further improve it and market it.

WEIGUANG MOU – CHIEF FINANCIAL OFFICER

My main role of the project was design and build *DreamBox* mechanic system. As an electronic engineering, I must admit that my mechanical academic background is rather weak and did not provide much real help in the design process. There were always fear that we would not be able to make our platform run properly. Nevertheless, we persevered and ended up learning a lot about soldering, cutting and other hands-on technical knowledge. Moreover, determining what parts will fit our needs, and where to order them is also very challenging. Many simple parts such as gears were a lot more difficult to obtain than imagined. We have to rebuild all crystal bars at the beginning of March due to motor size is larger than we expect. In order to save shipping time and money, we drove to US to pick up our parts. Finally, with great effort from each member of our team, we were able to finish and test our prototype to prove that our design actually worked. It was a challenging and exciting experience, but at the same time, harsh and difficult.

I was also in charge of working on design LED patterns. I made six LED patterns which will be random chose and displayed when the platform is in idle state. I have gained lots of valuable experience on microcontroller development such as PWM channel design and TIMER interrupt.

Working with our team members was an excellent experience. We had different focuses and different concentrations. Meetings were held regularly to discuss progress reports, design and implementation issues. Every member in the group is always available to share ideas and help each other. We all treated each other with respect and everyone worked equally as hard on the project. Without the strong team dynamic, it would be impossible to complete this challenging and time consuming project. I would like to thanks all my team members for their hard work to make our project so successful.

7. CONCLUSION

Mutrix Technology consists of five talented fifth-year engineering students who have been working diligently to build an innovative music statue for the purpose of enhancing the enjoyment of listening music. Healthy team dynamics and good teamwork are the keys to the success of the project. All members are proud of their accomplishments and they will continue working on the prototype for future improvement.