Virtual Orchestras:
Engineering Innovation and Musicians Collide

Kathleen M. Kaplan, D.Sc., John A. McGuire, M.A.,
Lt Col John J. Kaplan (Ph.D., J.D.) USAF

Howard University/University of Northern Colorado/USAF

Introduction

Will engineering technology replace musical artists? This replacement nearly occurred in January 2004 when Sir Cameron Mackintosh threatened to replace part of the London Orchestra in the musical *Les Miserables* with a "virtual orchestra." Yet, to attend the opera and hearing synthesized music performed is akin to viewing lip-synching arias! Strange as it seems, musicians are being virtualized. The New York City musician strike of May 2003 resulted in not a reduction of nine "pit" musicians, as the theaters had proposed, but a slash of six. To fill in the void of the missing pit musicians, virtual musicians are used.

There is overwhelming empirical evidence that link engineering and music, but this is the first time in history where engineering innovations may render musicians obsolete. In fact, "virtual orchestras" may be the wave of the future. A pit musician costs around $88,000 a year. The small reduction mentioned above, substituting six pit musicians with virtual musicians, will save a theater over $500,000 a year. That figure reflects merely the monetary amount saved; not included are other intangibles, such as the stress of human problems that may occur with the musician. Why wouldn't a theater want a virtual orchestra?

Some say that virtual orchestras do not give the same quality performance of live musicians, but isn't it possible to measure the quality of a performance based on engineering principles? Isn't a note a vibration and thus quantifiable? What about the ethical responsibility of engineering technology? Shouldn't we as engineers be responsible for our inventions?

These are just some of the questions, mirroring the subjective and objective issues raised by the use of virtual orchestras, that this paper addresses. Included are discussions of the current trend of virtual musicians, the possibility of virtual orchestras, and the ethical concerns surrounding this engineering technology and its use.

ABET – Relating Engineering and Music

An interesting relationship between music and engineering was found by the authors' review of ABET criteria and was originally given in [6].

Reviewing the guidelines specified by the Accreditation Board Engineering Technology (ABET), one notices a correlation between these guidelines and music. In the ABET 2004-2005 criteria for "Accrediting Engineering Programs," the "Program Criteria for Electrical, Computer, and Similarly Named Engineering Programs" section states in "Criterion 3. Program Outcomes and Assessment" specifically that "Engineering programs must demonstrate that their graduates have: (a) an ability to apply knowledge of mathematics, science, and engineering; (b) an ability to design and conduct experiments, as well as to analyze and interpret data; (c) an ability to design a system, component, or process to meet desired needs; (d) an ability to function on multi-disciplinary teams; (e) an ability to identify, formulate, and solve engineering problems; (f) an understanding of professional and ethical responsibility; (g) an ability to communicate effectively; (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context; (i) a recognition of the need for, and an ability to engage in life-long learning; (j) a knowledge of contemporary issues; (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice" [1].

By juxtaposing these criteria with music, a definite relationship can be seen, as in Table 1. In this table, suppose "engineering" was substituted with "music."

Table 1. Relationship between ABET Criteria and Music
(Imagine substituting "Music" for "Engineering") [6]

ABET Criterion 3 Specification	Relation in Music
(a) an ability to apply knowledge of mathematics, science, and engineering	Mathematics and music are related; notes for example are whole or a fraction
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	Music is composed, analyzed and interpreted
(c) an ability to design a system, component, or process to meet desired needs	Music is played on instruments, specifically designed to "meet desired needs"
(d) an ability to function on multi-disciplinary teams	An orchestra is a multi-disciplinary team (winds, strings, etc.)
(e) an ability to identify, formulate, and solve engineering problems	Musicians must be able to understand problems that occur in music (such as level of crescendo)
(f) an understanding of professional and ethical responsibility	Musicians must be professionals and ethical; changing music to fit the musician is frowned upon
(g) an ability to communicate effectively	Music is about communication
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context	Learning music is a difficult pursuit and a broad education is necessary to fully understand all its complex parts
(i) a recognition of the need for, and an ability to engage in life-long learning	Music is a life-long pursuit
(j) a knowledge of contemporary issues	Music is contemporary as well as historic
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	There are certain techniques, skills, and tools that musicians must apply for their practice.

Table 1 proves that an intrinsic relationship can be found between the concepts of engineering and the concepts of music. A substitution of "music" for "engineering" in some of ABET's criteria relates the two quite clearly.

The Current Trend of Virtual Orchestras

In January 2004, Sir Cameron Mackintosh threatened to replace part of the London Orchestra in the musical *Les Miserables* with a "virtual orchestra" [3]. Yet, to attend the opera and hearing synthesized music performed is akin to viewing lip-synching arias! Even the musicians themselves state, "steals jobs and cheats audiences" [3]. This, though, is not the only case of musicians being "virtualized." The New York City musician strike of May 2003 resulted in not a reduction of nine "pit" musicians, as the theaters had proposed, but a slash of six [8]. To fill in the void of the missing pit musicians, virtual musicians are used.

Even the opera is not safe from virtual orchestras. Recently, Mozart's Magic Flute, an opera performed in New York, used a virtual orchestra. The Local 802 of the American Federation of Musicians, the largest local union of professional musicians in the world, sent an e-mail protest blitz, but the show went on [5]. Other protests have been held by Local 802, including legal injunctions [2].

Recently, the authors attended "A Christmas Carol" at Ford's Theater in Washington DC. The entire orchestra was virtual. The production itself was wonderful, but we felt that it was missing something; the spontaneity of a live orchestra.

Monetary Benefit of Virtual Orchestras

Due to the cost savings, virtual orchestras may be the wave of the future. A pit musician costs around $88,000 a year. By substituting six pit musicians with virtual musicians, a theater will save over $500,000 a year. This savings may be passed onto the consumer, thereby reducing the ticket price of the performance. The ticket price reduction though will probably not be realized though. Ticket prices will most likely remain the same and the funds will be used for other purposes.

Canned Food and Music: Diminishing the Theater Experience

Erin Moore, a 16-year old theater enthusiast stated, "People don't like canned vegetables, why should they like canned music?" [8]. This sentiment is echoed by others. One attends the theater for a live experience. Movies, television, and recorded music are appreciated for their asynchronous, continual enjoyment. The theater is completely different. This medium is synchronous, at one with time and space, not to be duplicated exactly like a DVD. The experience is diminished if replaced by virtual orchestras.

Vibrations of Music

Notes are precise; they can be measured and quantified. There is nothing subjective about a specific note; a note is determined by the number of vibrations per second created. Pitch is another musical reference that can also be quantified; it refers to the high-low quality of a musical sound and is determined by the frequency of the tone, the number of vibrations per second [4].

Analog Versus Digital

The analog versus digital debate has been around for quite a while. A human voice, and any other natural sound, is analog. An analog signal can be represented as a series of sine waves, which of course, are continuous. It is interesting that the term, "analog," originated due to the analogous relationship between the fluctuations of the human voice,

or other transmitted sound, and the modulation of the carrier wave [9]. To represent sound by a digital form, the sound must be filtered, and then sampled at various intervals. A set of bits results, which is the digital representation of the analog sound signal. By sampling this often, the result will be a faithful representation of the original signal, and the human ear will not hear distortion.

Quantifiable Measures

The above two sections, Vibrations of Music and Analog Versus Digital, discuss the quantifiable measures of music, not those that are qualified. Musicians can go to a recording studio and have the sound produced engineered to be precise, but live performances do not have this benefit. So wouldn't virtual orchestras be better than live performances?

If one were to measure only the quantifiable, this would be true, but a live performance includes the excitement of nailing a note without technology! Virtual orchestras do not allow a note to be held longer, or a change in tempo, that would make the ordinary extraordinary.

Virtual Orchestras: A Violation of ABET Criteria

As engineers, we are required to "function on multi-disciplinary teams" and have "an understanding of professional and ethical responsibility." An orchestra is a multi-disciplinary team; it is a group of winds, strings, brass, and other instruments. Ethically, an engineer must have an understanding of his or her responsibility. A virtual orchestra adds no benefit, other than the potentially lower cost of tickets. Even given the possible lower cost, the theatrical experience is diminished, and the experience is not of the same quality. Thus, creating a virtual orchestra to replace a live orchestra is not ethical! Engineers must use their technology to enhance, not replace and diminish, systems. The theater is a system that has been stable for thousands of years; it needs no virtual enhancements of players.

Side Note: Itzhak Perlman and Virtual Accompanist?

Recently, the authors attended a concert by Itzhak Perlman, the classical violist, at The Music Center at the Strathmore [10]. His accompanist was the acclaimed pianist, Rohan DeSilva. This concert was spectacular! Could it have been enhanced though if Mr. Perlman was accompanied by a virtual accompanist? A virtual accompanist would not need a page turner, as Mr. DeSilva required. Mr. DeSilva probably played a wrong note, although we couldn't tell, but we would be assured that with a virtual accompanist, the notes would be "perfect." Also, a virtual accompanist may have reduced the cost of the Strathmore's ticket price, which was ninety-five dollars per seat in our special box section. Would these two factors have increased the quality of the performance? Perhaps Mr. Perlman would have received a few more standing ovations.

Of course, this is absurd. Yet, Itzhak Perlman with a virtual accompanist is as ridiculous as a Broadway show with a virtual orchestra. Engineers created this technology of virtual orchestras; we must be knowledgeable and responsible for the use of our inventions.

Conclusion

Itzhak Perlman, violinist virtuoso, with a virtual accompanist may be the disappointing future of "live" performances. Engineering technology may cause the extinction of musicians. While a virtual accompanist seems outlandish, virtual orchestras are becoming commonplace in the theater. Even if a theater does not completely replace the orchestra, it can replace at least some of the orchestra, as evident by New York City's resolution to allow replace six musicians.

This paper addressed the subjective and objective issues raised by the use of virtual orchestras. Also discussed was the current trend of virtual musicians, the possibility of virtual orchestras, and the ethical concerns surrounding this engineering technology and its use.

Cost has been the major consideration in using virtual orchestras; ethics has been a smaller concern, if that. We as engineers must adhere to ethical responsibility. It is not in our ethics to use our technology to replace that which has made the theater a thrilling experience: live musicians!

References

[1] Accreditation Board Engineering Technology (ABET), "Criteria for Accrediting Engineering Programs, Effective for Evaluations During the 2004-2005 Cycle," approved Nov. 1, 2003, http://www.abet.org/images/Criteria/E001%2004-05%20EAC%20Criteria%2011-20-03.pdf, accessed Mar. 2004.

[2] Associated Musicians of Greater New York, Local 802, accessed Dec. 2004, http://www.local802afm.org/.

[3] Ezard, John, "West End musicians fight threat of 'virtual orchestra'," *The Guardian (London)*, January 21, 2004, accessed Dec. 2004, http://www.atpam.com/Features/802_Negotiations_03.htm.

[4] Fink, Robert, The Natural Forces Bringing the "Do, Re, Mi, Scale" into Existence," *Origin of Music*, http://www.webster.sk.ca/GREENWICH/natbasis.htm, accessed Jan. 2004.

[5] Glanville, Justin, "Computerized Music Coming to the Opera," Red Nova, Aug. 6, 2003, accessed Dec. 2004, http://www.rednova.com/news/display/?id=8588.

[6] Kaplan, K., John A. McGuire, and John J. Kaplan, "The Music of Engineering," ASEE 2004 Conference Proceedings, June 2004.

[7] Music Notes Glossary, http://library.thinkquest.org/15413/glossary/glossary.htm?tqskip1=1, accessed Jan. 2004.

[8] Scherer, Ron, "A Broadway showstopper: musicians' strike," The Christian Science Monitor, May 10, 2003.

[9] TechTarget, "Analog," http://whatis.techtarget.com/definition/0,,sid9_gci211561,00.html, accessed February 27, 2005.

[10] Washington Performing Arts Society, The Music Center at Strathmore, Presentation of Itzhak Perlman, violin, and Rohan DeSilva, piano, February 20, 2005.

Biographical Information

KATHLEEN M. KAPLAN, D.Sc.
Dr. Kaplan is an Assistant Professor in the Department of Systems & Computer Science at Howard University. She is also a Registered Patent Agent licensed to practice before the United States Patent and Trademark Office. She can be reached at kkaplan@howard.edu.

JOHN A. McGUIRE, Ph.D. Candidate
Mr. McGuire is a Ph.D. Candidate studying music at the University of Northern Colorado. He can be reached at mcgu9459@blue.unco.edu.

JOHN J. KAPLAN, Ph.D., J.D.
Dr. Kaplan is a Lieutenant Colonel (Lt Col) in the United States Air Force and a Patent Attorney. Lt Col Kaplan is the Deputy Director of Policy and Integration at the Air Force Office of Scientific Research (AFOSR) in Arlington, Virginia. He can be reached at john.kaplan@afosr.af.mil.