LEA
Leonardo Electronic Almanac
Vol **15** Issue **01 – 02** **January** 2007

Music Technology at Stellenbosch University

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Keywords

Music technology, Stellenbosch University, African music studies

Abstract

This paper strives towards providing an understanding of, and insight into the music technology program hosted by the music department at Stellenbosch University. Being still quite a young and recent effort the paper adopts the form of an introductory presentation in which four lines of thought are explored. The theoretical and philosophical underpinnings which continuously inform the program shall be followed by an introduction to the program content and outcomes. In the third and fourth places the non-academic activities will be referred to and the presentation brought to a close by looking towards the future.

Introduction

The following introductory thoughts deal with the music technology program hosted by the Music Department at Stellenbosch University (www.sun.ac.za/music/).

Theoretical and philosophical underpinnings

In a 2003 publication, “Musical Arts in Africa — Theory, Practice and Education” [1], the author and Professor Andrew Tracey collaborated in writing a chapter with the title “Technology and African Music Studies”. Here it was maintained that the term “music technology”, yet to gain secure footing in the English language, took on different identities and meanings.

Divorced from the equally problematic term “music”, “technology” has been dissected by Grübler [2]. Here he breaks the Greek term *technologia*, often implying “systematic treatment”, down into *techne* and *logos*. The term’s knowledge and manufacturing base spawns what engineers and anthropologists refer to as “hardware” and “artefacts”. The latter obscures complex undercurrents related to production, “feedback loops” characterize its evolution, and technological change, although difficult to implement, influences society in complex ways.

Tracey’s exploration of musical instrument construction and maintenance in the above reference reflects the

definition and qualities of technology in all its diversity. Examples include the use of knife, chisel, axe, adze and 'gwengo' or side scraper and materials such as metals and woods with the latter chosen with particular care depending on which part of an instrument it was meant for. The same applies to materials chosen by virtue of the resonance, amplification, strength and other qualities. Examples include the altered timbre of Ganda ennanga lyres when not made with the increasingly scarce nswaswa skin, or nylon fishing line strung Gambian kora lutes and Malawian bangwe zithers. The list can be expanded by pointing to the use of floor polish as lubrication, board chalk as gripping agent, nylon instead of cow tendon, electrician's pitch or grease in the place of beeswax.

Viewed from another perspective, mechanical recording and media constitute further examples of the impact of technology and technological change on Africa. Interaction has not been smooth. From the earliest recordings around 1905 to the "phonograph", "LP", "cassette" and current digital age era, cultural alienation, exploitation and auditory "snapshot" mentality has been in conflict with the positive impact deriving from dissemination and democratization of cultural goods.

A music technology program rooted in this legacy faces challenges. These range from the impact of reactionary Luddism, and of a very real hemispherical technological divide to the reduction of cultural heritage to easily digestible sound-bite length portions.

Program Content Outline

Here, two points need to be taken into consideration. Firstly, both content and outcome are continuously assessed and therefore under development. Secondly, at undergraduate level the approach is almost purely theoretical, while a healthier balance between theoretical and practical work is struck at postgraduate level. Additional information, including module numbers, is available at www.sun.ac.za/musteg.

i) Undergraduate modules
In brief, the undergraduate program focuses on five topic areas. They concern the fundamental theoretical understanding of sound wave generation and propagation, technical issues pertaining to the manufacture, specifications and use of recording studio equipment, audio synthesis fundamentals and signal processing in both analogue and digital domains and digitization. Programming fundamentals, with the emphasis placed on Java, JSyn and Csound are taught concurrent to the undergraduate modules.

ii) Postgraduate progam

ii.i) Completed research

ii.i.i) One of the first research projects to be completed, developing a hyperinstrument with gesture interface for musical performance, was structured and executed against the background of the importance attached to ICT in the developing world. The researcher's experiences as musician and computer programming teacher, along with the supervisor's need for translating hand movement into control data, served as further motivation.

No local musicological research projects covering virtual environments, hyperinstruments or the interface between human gesture movement and computer systems were located during the literature search for this project. These and other key concepts such as mapping were investigated and an overview of operational examples supplied before defining two objectives. The secondary objective of this research project was to stimulate local research into human gesture and computer systems by limited means. The primary objective was to implement a cost-effective, non-haptic gesture application for musical performance and teaching purposes.

This implementation utilized EyesWeb and JSyn and took the form of three gesture-based systems. SystemOne was a hardware analog synthesizer controller, SystemTwo a virtual DJ equipment environment and SystemThree a Digidesign ProTools Midi controller.

The latter two, SystemTwo and SystemThree have had the most noticeable impact on the activities of the music technology group. SystemThree featured in the author's compositions "Skadu-musiek II", "Cassini" and "Cassini-Huygens" performed by the KEMUS ensemble. In all three instances it translated non-haptic hand movement tracked by a camera into control data in order to attain two goals. Firstly, the data controlled a digital software filter to manipulate the sound of one of the acoustic ensemble instrumentalist in real-time. Secondly, the data allowed for the real-time panning of an acoustic ensemble instrument in a 5.1 surround playback scenario.

Finally, SystemTwo has influenced the programming component of the undergraduate music technology program. An example of this has been a recent final semester assignment in which a "virtual doggy", or "Voggy" was designed to respond to its master's commands.

ii.i.ii) A lack of research engaging with local cinema triggered the first film music project, Paljas: 'n Filmklankteoretiese ondersoek. As was to be expected, the literature review for this study found that to date much of this scholarship on South African film music was politically inspired and motivated. Against this background it was decided to investigate aspects of the Afrikaans film Paljas in its capacity as recipient of local awards, and as it had been an official South African entry in the Best Foreign Film category at the Oscars. Further motivation was provided by the fact that the literature review produced only two brief descriptive published comments on the film's sound track, indicating that it had been largely ignored.

Departing from Landy's Organised Sound (Volume 4/1 1999) discussion of electroacoustic musicology, the researcher positioned the study approximately at the intersection where historical, systematic and ethno-electronic musicology meet. Closer investigation showed it as being oriented more towards systematic studies, shying away from philosophical or methodological approaches, feminism and post-colonial approaches. Finally, although not constituting a semiotic study, it could be regarded as affiliated to an internalist-semantic approach.

The positioning of the study was followed by a review of film theories in order to arrive at the film sound theories of Bazin, Balász and Kracauer. An introduction to graphical representations of sound then prepared the ground for subjecting the Paljas sound track to a spectrographic, and, in part, graphic analysis. The outcome of this process was then mated to film sound theories of the above theorists in order to draw conclusions.

ii.i.iii) Excerpts from six operas, Tosca, Norma, Madama Butterfly, Macbeth and La Traviata formed the core around which the project In search of the "true" sound of an artist: a study of recordings by Maria Callas revolved. A literature study and the sourcing of recordings from which to make an initial selection followed by two comparison stages formed early stations in the research methodology. Frequency spectrum and pitch analysis of samples from the selected recordings followed, as did the corroboration and validation of data and findings. Presented as a flow diagram these steps along with closing remarks embodied the research methodology followed in, and acted as backbone to, the project.

The project itself was rooted in a discussion of the ethics, aesthetics, technical issues and matters concerning authenticity in the process of restoring, remastering and re-releasing older recordings. This was a logical step as it concerned itself with the sometimes problematic re-releases of remastered Callas performances, a debate that had enjoyed wide media coverage, as the literature study had shown. A discussion of the "voice of the century" followed, Callas' early training, vocal qualities, meteoric career and legacy, encompassing views from

detractors and admirers. The first part of the thesis concluded with a synopsis of her recording career with EMI. Four Addenda accompanied the thesis of which the first, an annotated discography, was meant to be read in conjunction with this chapter.

The opera analyses chapters essentially stuck to the same format. A technical analysis followed 14 steps which included the identification and importation of waveforms, plotting timeshifts and cross-correlations, executing FFT transfer functions with suitable Hanning window and additional analysis in Matlab using an algorithm based on the cross-correlation function. This technical analysis was used to corroborate more subjective impressions concerning the sound of Callas' voice in sections of the remastered and re-released recordings.

ii.i.iv) From the title Automatic music transcription — an exploratory study it can be deduced that at least one of the completed research projects concerned itself with AMT, one of the most challenging music technology problems. A Faculty of Engineering researcher investigated the theoretical underpinnings of polyphonic music transcription and implemented a workable system.

The project departed from the premise that AMT received little attention compared to speech and image processing in the field of DSP, particularly in South Africa. This study aimed to lay the foundation for future local research against this background, while taking cognizance of the fact that an all-encompassing solution to the AMT-challenge was not in sight.

In the final analysis this study revolved around a heuristic-based, frequency-domain, multi-pitch estimator which included a non-linear spectral smoothing algorithm for detecting spectral peaks. Acoustic polyphonic signals were convincingly transcribed, while accuracy with synthesized polyphonic signals served as evidence for the correctness of the underlying approach. Algorithms developed for note duration quantization, polyphony estimation, key identification and the elimination of soft notes may well enhance accuracy in other transcription systems. Perhaps the important contribution was the fact that most processing levels were contributed to with the result that the study provided an overview of many problematic aspects as they were encountered.

ii.i.v) The first postgraduate project to be completed, research into and design of a sound sample library, concerned the design and recording of a Gretsch Renown Maple drum kit sample library for the GigaStudio platform. Motivation for this study revolved around the potential harboured by the specific platform, limited methodological guidelines and the researcher's experiences as composer, arranger and producer. Two components made up the final project documentation, a written thesis and a sound sample library. In the case of the latter, a professional session musician was recorded in three locations in the music department, the floating studio with "live room" sound; the Fismer Hall, a medium-sized rehearsal and chamber music room and the Endler Hall, a 556 seat concert facility. A selection of samples covering a range of playing techniques were mastered and packaged, and have since been used in commercial projects.

ii.i.vi) In Musical networks — the case for a neural network methodology in advertisement music research the researcher took as point of departure the limited body of research that existed on functional, context specific advertisement music. This explorative pilot study questioned generalized earlier findings regarding music for advertisements. A multidisciplinary perspective, drawing on the Psychology of Music, Consumer Science and the Cognitive Sciences formed the backdrop against which to formulate an hypothesis. Far from proposing a watertight "award-winning" composition recipe, it was proposed that the concepts specified context and functional commercial music harboured unlocked potential.

Taking Cognitive Systematic Musicology, a subdiscipline of Cognitive Science as main paradigm, research questions concerning the universals at play in affective reactivity to South African television advertisement music were investigated. Seven dependent variables covered in the thesis text were assigned to serve as inputs

in the design of a flexible and extendable multilayered, feedforward ANN employing a backpropagation learning algorithm. Four units were included in the hidden layer and the output layer consisted of two layers, "Music functional" and "Music not functional".

The study concluded with a demonstration of the feasibility of encoding the model in MATLAB's Neural Network Toolbox, with suggestions for collecting training data and an example of a questionnaire as measuring instrument.

ii.i.vii) Applying the phi ratio in designing a musical scale investigated the suitability of the phi ratio as determining factor in constructing an aesthetically pleasing musical scale. As was the case in the majority of research projects, a secondary objective was implied along with the principal outcome. In this case it was the implementation of the "IPEM Toolbox" in order to measure the degree of auditory roughness associated with the "phi scale".

The researcher proceeded by pointing to the importance of ratios in human endeavour. This was followed by mathematical properties such as phi being irrational, its role in the formation of the golden rectangle and the manner in which Fibonacci ratios converged towards it. An investigation of the role of phi in phyllotactic leave, petal and seed arrangements, or biological occurrences, came next. This section closed by taking stock of the importance of ratios in art and architecture. Le Corbusier's "Modulor" system, relying on the proportions inherent to an upright body with upwardly extended arm, served as an example.

Two steps were then taken to arrive at a practical musical application. Firstly, a discussion of auditory consonance and dissonance was followed by an overview of what historically constituted musical consonance. An exploration of the perception of degrees of pleasingness of intervals, or "sensory consonance" was followed by a discussion of auditory perception. In turn, this led to the investigation of theories of psychoacoustic properties of sound perception.

Secondly there followed two chapters, one on tuning systems, the other concerned with the construction of a musical scale. In view of the multitude of currently used scale systems the former laid no claim to being comprehensive. Rather, those tuning systems perceding the equal-tempered scale were selected from the earlier discussion on the history of consonance. In the latter the researcher argued against characteristics of inborn auditory perception of intervals forming a foundation for scale construction. Rather, seven criteria, "discriminability of intervals", "octave equivalence", "limited pitch number", "uniform modular pitch interval", "maximal intervallic variety", "preserving coherence" and "optimizing consonance during interval choice" were proposed as guidelines.

Experimentation showed that if the third root of phi determined the relation between a reference tone's fundamental and partials, Sethares' "curve mapping program", available at http://eceserv0.ece.wisc.edu/~sethares/comprog.html, calculated usable "roughness minima" or "consonance maxima" points. Used as scale step points, factors such as spectral energy level and step number were satisfactorily accommodated. The resulting scale was rendered in Csound and mapped for use in GigaStudio.

In the final analysis the "phi scale" met most of the above seven criteria, octave equivalence excluded. Furthermore, the 'IPEMRoughnessFFT' program from the "IPEM Toolbox" showed that for consecutive scale steps, auditory roughness measurements fell within acceptable limits.

ii.ii) Current research

Current postgraduate projects investigate aspects of audio restoration, foley, music in the French "new wave"

cinema, trance electronic dance music and surround sound. Of particular interest is a Faculty of Engineering computerized vocal training aid project currently underway. Despite having been studied for a number of years, such systems remain hampered by unresolved accuracy and reliability issues which limit their quality and usefulness. In light of these unresolved areas of research, the possibilities and development of a basic sight-singing tutor system using a statistical approach is suggested. Notes are individually modeled by Hidden Markov Models (HMM's), with models being added for different pronunciations and/or vibrato. The models will be trained using feature vectors. The singer will be asked to sing a predetermined vocal exercise and the input waveform is then segmented by finding the optimal path through the network of HMM's. User feedback is generated by determining the degree to which the pitch of the vocal input waveform matches that of the prior musical reference.

Non-academic activities, future plans

Founded in 1980 under the guidance of Edward Aitchison, the contemporary music society KEMUS (www.sun.ac.za/musteg/kemus) at that time concerned herself primarily with facilitating performances of compositions by contemporary South African composers. The author's involvement with the ensemble dates back to around 1995. It was then decided to initiate performances of 20th century repertoire that stood little chance to be heard locally. Compositions that come to mind include Webern Five Orchestral Pieces Op. 10, Varese Ionisation, Piños Stella Matutina, Karkoschka mit/gegen sich selbst and Stockhausen Mikrophonie I.

Perhaps the following brief descriptions of two of the author's works convey a degree of insight into KEMUS' sound world at this point in time.

Cassini utilizes a sampled percussion and voice sound track along with live percussion and viola as sound sources. Technically, it relies on two non-haptic gesture interface applications. Eyesweb (www.eyesweb.org), via a digital camera translates hand movement into data which interfaces with MIDI data. The MIDI data, allowing virtually unlimited control, in this instance allows a performer to filter the Viola signal in real time with a Didgidesign ProTools Focusrite filter. The quadraphonic panorama placement of the piano sound is facilitated in the same manner. A LAN also facilitates the use of CoolEdit and Csound (www.csounds.com) for live sound manipulation. Audio example 1 is a 45-second extract (706kb) from this work (http://leoalmanac.org/journal/Vol_15/lea_v15_n01-02/av/THerbstAudio01.mp3)

Cassini-Huygens (http://leoalmanac.org/journal/Vol_15/lea_v15_n01-02/av/THerbstAudio02.mp3) served as sound track (706kb) to a short film John and Jenny by a student from the Fine Arts department at Stellenbosch University. It employs the same instrumentation and technical set-up as Cassini and is intended as a study towards the next project, Cassini-Huygens II. The intention here will be to resort to a neural net in order for a degree of artificial intelligence to be incorporated in the improvisatory programming aspect.

Finally, the recording studio and music department collaborate in hosting Conserve Digital, a commercial CD-label. However, the bigger music technology project sees itself as subscribing to a broader mandate. Here the promotion of FOSS values in an Ubuntu Linux 7.1 surround sound venue has been a priority.

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Author Biography

Theo Herbst studied at the Stellenbosch University (BMus 1986), the University of Natal (MMus 1988) and at the Staatliche Hochschule für Musik und Darstellende Kunst , Stuttgart (KA Prüfung 1993). At present he is enrolled at the Katholieke Universiteit Leuven for his Doctoral studies. Since 1994 he has held a post as lecturer in the Music Department of the Stellenbosch University. Here he teaches a wide range of courses covering 19th and 20th century Music Theory, Composition, Aural Training and Music Technology.

Citation reference for this Leonardo Electronic Almanac Essay

MLA Style
Herbst, Theo. "Music Technology at Stellenbosch University." "Unyazi" Special Issue, Leonardo Electronic Almanac Vol. 15, No. 1 - 2 (2007). 1 Jan. 2007 <http://leoalmanac.org/journal/vol_15/lea_v15_n01-02/therbst.asp>.

APA Style
Herbst, Theo. (Jan. 2007) "Music Technology at Stellenbosch University," "Unyazi" Special Issue, Leonardo Electronic Almanac Vol 15, No. 1 - 2 (2007). Retrieved 1 Jan. 2007 from <http://leoalmanac.org/journal/vol_15/lea_v15_n01-02/therbst.asp>.

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Leonardo Electronic Almanac (ISSN: 1071 4391)

Nisar Keshvani, Editor-in-Chief

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