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Analysis of Music with Information Theory

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Summary

Information Theory is an important element in many sciences and technologies. The aim of this research is to investigate the application of Information Theory as a method of analysing aspects of music with the purpose of developing models of selected characteristics in compositions.

The candidate developed computer software to apply the principles of Information Theory to analyse pitch distribution, interval distribution, rhythmic content, and a combination of pitch and rhythm. Results obtained with the analyses were applied to develop statistical and graphical models of music. The programmes comprise three independent programmes: a graphical interface for entering the information, a second programme calculates the entropy values by applying analytical routines to the musical information. A third programme generates the tables and graphical models from the information obtained with the analyses programmes, in a variety of formats. Although each programme may be used independently, they are mainly designed for use as a single application in which the individual programmes are totally transparent.

Twenty-two compositions, categorised into three stylistic groups, were analysed with the computer programmes. The three groups are Contemporary Popular songs, Classical Art songs and Art songs of the twentieth century. The selection of the first two groups was based on their continued popularity ratings as indicated by the availability of recordings. In the case of the Contemporary Popular songs the availability of printed scores was also a criterium. Unfamiliar songs were selected for the third group.

After the generation of the entropy values of the songs, a combination of the resultant entropy values was compiled in both tabular and graphical formats.

Each of the individual songs generated unique entropy and stochastic values — an indication of their unique characteristics. To obtain the average, and maximum and minimum values for each group of compositions, the entropy and stochastic results for the individual compositions in each group were combined to develop further tabular and graphical models. The minimum and maximum entropy and stochastic values differ significantly for each of the groups. The contemporary popular songs show the largest numbers of stochastic orders and the highest redundancy values; the contemporary art songs generated the lowest number of stochastic orders and the lowest redundancy values. With one exception — Franz Schubert's *Ave Maria* — the classical art songs generated entropy values and stochastic orders that, with some overlapping, fall between the highest value of the contemporary popular songs and the lowest values of the contemporary art song group. *Ave Maria*, which has found considerable popularity as a contemporary popular song, generated values that overlap with both that of the popular song group as well as that of the classical art song.

This research shows that statistical models of specific compositions as well as music styles may be generated with Information Theory. Using the methods described in this dissertation the characteristics of individual compositions may be compared with models representing specific musical characteristics and styles.

analysis, computer, information, intervals, melody, model, music, pitch, popular, predictability, rhythm, statistics, style, unpredictability

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Opsomming

Informasie Teorie het noodsaaklike toepassings gevind in vele tegnologieë en wetenskappe. Met hierdie navorsing word die toepassing van Informasie Teorie, om sekere aspekte van musiek te analiseer, ondersoek. Die doel is om vas te stel of modelle van kenmerkende aspekte van musiek daarmee ontwikkel kan word.

Rekenaarprogrammatuur is deur die kandidaat ontwikkel om die beginsels van Informasie Teorie op analise van toonhoogtes, intervale, en ritmiese inhoud, asook n kombinasie van toonhoogte en ritme van musiek toe te pas. Die resultate van die toepassing is gebruik vir die skep van statistiese en grafiese modelle. Die programmatuur bestaan uit drie selfstandige rekenaarprogramme: 'n grafiese koppelvlak, waarmee die musikale inligting in die databank van die rekenaar gevoer word, 'n tweede program bereken die entropiewaardes deur die toepassing van die analitiese algoritmes op die musikale inligting. Die derde program is verantwoordelik vir die daarstelling van die tabulêre en grafiese modelle in 'n verskeidenheid formate. Die genoemde programme kan onafhanklik gebruik word, maar is ontwerp om hoofsaaklik as 'n eenheid gebruik te word.

Twee-en-twintig komposisies, wat aan drie verskillende stilistiese groepe behoort, is gebruik vir die ontleding met die rekenaarprogrammatuur. Die drie stylgroepe is: hedendaagse populêre musiek, kunsliedere uit die Klassieke tydperk, en kunsliedere van die twintigste eeu. Die seleksie van die eerste twee groepe was volgens populariteit soos aangedui deur die aantal opnames op plaat en CD wat daarvan beskikbaar is. In die geval van die hedendaagse populêre musiek is die beskikbaarheid van gepubliseerde musiek ook in ag geneem. Die derde groep is algemeen onbekende werke.

Nadat die entropiewaardes van elke komposisie bereken is, is dit in tabulêre en grafiese formaat saamgestel.

Elk van die individuele komposisies het unieke entropie-resultate gelewer. Om die gemiddelde, maksimum, en minimum waardes van elk van die groepe te verkry, is die entropiese en stochastiese waardes van die individuele komposisies in elke groep, gekombineer en verdere tabulêre en grafiese modelle geskep. Die minimum en maksimum entropiese en stochastiese waardes van elk van die groepe verskil kenmerkend van mekaar. Die hedendaagse populêre musiek toon die hoogste aantal stochastiese reekse met die hoogste oortolligheidswaardes; die groep hedendaagse kunsliedere het die laagste aantal stochastiese reekse teenoor asook die laagste oortolligheidswaardes. Met een uitsondering — Franz Schubert se *Ave Maria* — het die Klassieke kunslied stochastiese reekse en entropiewaardes getoon wat, met 'n mate van oorvleueling, tussen die hoogste waardes van die hedendaagse populêre groep en die laagste waardes van die hedendaagse kunslied-groep lê. *Ave Maria*, wat ook baie bekendheid verwerf het as populêre musiek, het waardes getoon wat oorvleuel met die waardes van beide die hedendaagse populêre groep en die Klassieke kunslied.

Hierdie navorsing toon aan dat statistiese modelle van individuele komposisies sowel as van musikale style met behulp van Informasie Teorie ontwikkel kan word. Die toepassing van die metodes wat in hierdie dissertasie beskryf word, maak dit moontlik om stylkenmerke van individuele komposisies te vergelyk met modelle wat spesifieke karaktertrekke van musiek verteenwoordig.

analise, informasie, intervale, melodie, model, musiek, onvoorspelbaarheid, populêr, rekenaar, ritme, statistiek, styl, toonhoogte, voorspelbaarheid,

Figure 8-22. Interval entropies for Bluebird song in

Figure 8-23. Interval entropies for 16 Classical lieder

Figure 8-24. Interval entropies for 19th-century jazz

Figure 8-25. Interval entropies for Being young and green

Figure 8-26. Interval entropies for I have an old dream

Table of figures

Figure 2-1. Unidirectional communication model	2-2
Figure 2-2. Model for music as communication channel	2-4
Figure 2-3. Mole's model of semantic and aesthetic Information	2-9
Figure 2-4. Decision-making tree	2-12
Figure 3-1. Entropy for a set of two symbols with changing probabilities	3-11
Figure 3-2. Entropy for a set of four symbols with varying illustrative probabilities	3-12
Figure 5-1. Databases and primary programmes for music analysis	5-5
Figure 5-2. Main screen of the analysis programme	5-5
Figure 5-3. Data entry screen	5-7
Figure 5-4. Entropy values in graph format	5-8
Figure 5-5. Entropy values in data-sheet view	5-9
Figure 5-6. Flowchart for the analysis of pitch or note values	5-17
Figure 5-7. Flowchart for combined pitch and duration analysis	5-18
Figure 5-8. Flowchart for stochastic melody analysis	5-20
Figure 5-9. Flowchart for the calculation of entropy	5-23
Figure 6-1. Maximum and minimum ranges for the pitch-ratio entropies	6-9
Figure 6-2. Maximum and minimum ranges for the pitch-rhythm entropies	6-11
Figure 6-3. Maximum and minimum ranges for the first order rhythm entropies	6-12
Figure 6-4. Maximum and minimum range of average entropy values	6-14
Figure 6-5. Interval entropies for <i>Summer love</i>	6-17
Figure 6-6. Interval entropies for <i>Love letters</i>	6-18
Figure 6-7. Interval entropies for <i>Annie's song</i>	6-18
Figure 6-8. Interval entropies for <i>You are the sunshine of my life</i>	6-18
Figure 6-9. Interval entropies for <i>Thank you for the music</i>	6-19
Figure 6-10. Interval entropies for <i>One more night</i>	6-19
Figure 6-11. Interval entropies for <i>Sleepy shores</i>	6-19
Figure 6-12. Interval entropies for <i>Ave Maria</i>	6-20
Figure 6-13. Interval entropies for <i>Nachtigall</i>	6-20
Figure 6-14. Interval entropies for <i>Das ist ein Flöten</i>	6-20
Figure 6-15. Interval entropies for <i>Das Wandern</i>	6-21
Figure 6-16. Interval entropies for <i>Halt</i>	6-21
Figure 6-17. Interval entropies for <i>Ich will meine Seele</i>	6-21
Figure 6-18. Interval entropies for <i>Liebestreu</i>	6-22
Figure 6-19. Interval entropies for <i>Rosamunde</i>	6-22
Figure 6-20. Interval entropies for <i>Cupid and my Campaspe</i>	6-22
Figure 6-21. Interval entropies for <i>Since she whom I love</i>	6-23
Figure 6-22. Interval entropies for <i>How love came in</i>	6-23
Figure 6-23. Interval entropies for <i>In Flanders fields</i>	6-23
Figure 6-24. Interval entropies for <i>Whenas the rye</i>	6-24
Figure 6-25. Interval entropies for <i>Being young and green</i>	6-24
Figure 6-26. Interval entropies for <i>Nun ich der Riesen</i>	6-24

v

Figure 6-27. Rhythmic entropies for <i>Summer love</i>	6-28
Figure 6-28. Rhythmic entropies for <i>You are the sunshine of my life</i>	6-28
Figure 6-29. Rhythmic entropies for <i>Annie's song</i>	6-28
Figure 6-30. Rhythmic entropy for <i>Love letters</i>	6-29
Figure 6-31. Rhythmic entropies for <i>Thank you for the music</i>	6-29
Figure 6-32. Rhythmic entropies for <i>One more night</i>	6-29
Figure 6-33. Rhythmic entropies for <i>Sleepy shores</i>	6-30
Figure 6-34. Rhythmic entropies for <i>Ave Maria</i>	6-30
Figure 6-35. Rhythmic entropies for <i>Nachtigall</i>	6-30
Figure 6-36. Rhythmic entropies for <i>Ich will meine Seele</i>	6-31
Figure 6-37. Rhythmic entropies for <i>Das ist ein Flöten</i>	6-31
Figure 6-38. Rhythmic entropies for <i>Das Wandern</i>	6-31
Figure 6-39. Rhythmic entropies for <i>Halt</i>	6-32
Figure 6-40. Rhythmic entropies for <i>Liebestreu</i>	6-32
Figure 6-41. Rhythmic Entropies for <i>Rosamunde</i>	6-32
Figure 6-42. Rhythmic entropies for <i>Since she whom I loved</i>	6-33
Figure 6-43. Rhythmic entropies for <i>Cupid and my Campaspe</i>	6-33
Figure 6-44. Rhythmic entropies for <i>How love came in</i>	6-33
Figure 6-45. Rhythmic entropies for <i>In Flanders fields</i>	6-34
Figure 6-46. Rhythmic entropies for <i>Whenas the rye</i>	6-34
Figure 6-47. Rhythmic entropies for <i>Being young and green</i>	6-34
Figure 6-48. Rhythmic entropies for <i>Nun ich der Riesen</i>	6-35
Figure 6-49. Graphical model of the combined entropy values of the P-group	6-39
Figure 6-50. Graphical model of the combined entropy values of the S-group	6-39
Figure 6-51. Graphical model of the combined entropy values of the M-group	6-40
Figure 7-1. Comparison of pitch entropies for three selected songs	7-3
Figure 7-2. Comparison of pitch and rhythm entropies for three selected songs	7-4
Figure 7-3. Comparison of pitch, rhythm and pitch-rhythm entropies for three selected songs	7-4
Figure 7-4. Comparison of pitch, rhythm, pitch- rhythm, and pitch ratio entropies for three selected songs	7-5
Figure 7-5. Interval entropies of the three compositions	7-8
Figure 7-6. Rhythm entropies of three compositions	7-9
Figure 7-7. Combined entropies for <i>You are the sunshine of my life</i>	7-10
Figure 7-8. Combined entropies for <i>Das ist ein Flöten</i>	7-11
Figure 7-9. Combined entropies for <i>Since she whom I loved</i>	7-12

Table of equations

Equation 3-1. Boltzmann's formula	3-3
Equation 3-2. Maximum information of a set of symbols	3-5
Equation 3-3. Information of a single note from a set of seven notes	3-5
Equation 3-4. Information of a single note of seven using logarithms	3-5
Equation 3-5. Information of a single element using natural logarithms	3-6
Equation 3-6. Calculation of information using binary logarithms	3-6
Equation 3-7. Information for x number of symbols in Hartley's	3-6
Equation 3-8. Symmetry of the H function in every p_k	3-10
Equation 3-9. Extremal properties	3-10
Equation 3-10. Shannon's formula for information in a stochastic process	3-10
Equation 3-11. Relative entropy	3-13
Equation 3-12. Absolute redundancy	3-14
Equation 3-13. Relative redundancy	3-14
Equation 5-1. Total elements in an array	5-22
Equation 5-2. Element proportions of total elements	5-22
Equation 5-3. Calculation of the entropy of a set of values	5-22
Equation 5-4. Calculation of Maximum Entropy	5-23
Equation 5-5. Calculation of relative Entropy	5-23
Equation 5-6. Calculation of relatively Redundancy	5-23
Table 7-1. Entropy of pitch distribution for three selected songs	7-3
Table 7-2. Rhythm entropy for three selected songs	7-3
Table 7-3. Combined pitch and rhythm entropy for three selected songs	7-4
Table 7-4. Pitch RMS entropy for three selected songs	7-5
Table 7-5. Stochastic interval entropies for three compositions	7-7
Table 7-6. Stochastic rhythm entropies for three compositions	7-8

Table of tables

Table 4-1. Calculation of the note values for the <i>Illiac Suite</i> by L. A. Hiller and L. M. Isaacson	4-12
Table 5-1. Hewlett pitch values	5-12
Table 5-2. Numerical values of accidentals	5-12
Table 5-3. Pitches and their representative HR numbers	5-12
Table 5-4. HR numbers for the G major scale	5-12
Table 5-5. Interval values derived from HR numbers	5-14
Table 5-6. DARMS and MUSTRAN note duration codes	5-15
Table 5-7. Adapted MUSTRAN note value system	5-15
Table 5-8. Variables used in the stochastic analysis programme	5-19
Table 5-9. Illustrative values in an element array	5-21
Table 6-1. Pitch entropies for the three composition groups	6-7
Table 6-2. Pitch ratio entropies for the three composition groups	6-9
Table 6-3. Pitch-rhythm entropies for the three composition groups	6-10
Table 6-4. Rhythmic entropies for the first order for the three composition groups	6-11
Table 6-5. Summary of pitch and rhythm entropy values	6-13
Table 6-6. Comparative Interval-Order quantities	6-16
Table 6-7. Entropy values for stochastic interval sequences, order 1 - 15	6-25
Table 6-8. Comparative rhythm-orders	6-27
Table 6-9. Combined rhythmic entropies for orders 1 - 15	6-36
Table 7-1. Entropy of pitch distribution for the three selected songs	7-3
Table 7-2. Rhythm entropy for three selected songs	7-3
Table 7-3. Combined pitch and rhythm entropy for three selected songs	7-4
Table 7-4. Pitch ratio entropy for three selected songs	7-5
Table 7-5. Stochastic interval entropies for three compositions	7-7
Table 7-6. Stochastic rhythm entropies for three compositions	7-8

Table of examples

Example 4-1. <i>Illiac Suite</i> : Experiment I, L. A. Hiller and L. M. Isaacson	4-12
Example 4-2. <i>Illiac Suite</i> : Experiment II, L. A. Hiller and L. M. Isaacson	4-13
Example 4-3. <i>Illiac Suite</i> : Experiment III, L. A. Hiller and L. M. Isaacson	4-14
Example 4-4. <i>Illiac Suite</i> : Experiment IV, L. A. Hiller and L. M. Isaacson	4-15
Example 4-5. Stochastic String Quartet, James Tenney	4-17

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The *Harvard Dictionary of Music* defines musical style as follows:

In a musical composition, 'style' refers to the methods of treating all the elements — form, melody, rhythm, etc. In practice, the term may be applied to single works, ... to composers, ... to types of compositions, ... to media, ... to methods of composition. ... (April 1993, pp. 311-12)