Musical Informatics: an Emerging Discipline?

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Résumé. L'ordinateur est utilisé de manière très efficace pour la composition musicale. Ce n'est pas le cas en musicologie. Une des raisons en est que les musicologues réclament une représentation informatique des formes de données et des modes de développement courants en musicologie, tandis que les compositeurs ne s'intéressent qu'aux formes originales de données et de modes de développement. Il est bien connu que l'ordinateur impose des contraintes d'exactitude et de formulation explicite, et alors qu'elles ont été un excitant pour l'imagination des compositeurs, elles ont créé des difficultés aux musicologues qui s'en remettent ordinairement à un type de connaissance ayant un caractère extrêmement implicite et imprimé. La généralisation de solutions particulières à ces difficultés fait naître une nouvelle discipline, l'informatique musicale, qui a pour but de décrire précisément les données et techniques musicales ainsi que leur mise en œuvre dans un logiciel informatique. Quelques-unes des publications concernant cette discipline, particulièrement dans le champ de la représentation des rapports de hauteur et de la traduction correcte de fragments mélodiques, sont traitées en référence avec la tentative faite par la musicologue Eleanor Selfridge-Field de trouver des correspondances avec un fragment mélodique commun dans un index généré par ordinateur d'incipits mélodiques, et en référence avec nos commentaires sur la raison pour laquelle la plupart des correspondances trouvées ne sont pas de vraies correspondances.

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Mots-clés : informatique musicale, représentation de la hauteur, correspondance mélodique, musicologie computationnelle.

Computers have been used in music-making since the earliest days of the technology. In this they form only the latest in a long line of musical machines, from elaborate musical clocks such as Mozart wrote for in the eighteenth century to the aeolian harps and wind chimes of even ancient cultures. What is the fascination? If there are perfectly good human musicians why use a machine, especially when “mechanical” is a common pejorative description of sub-standard musical performance? Perhaps the fascination derives from the very non-humanity of the machine. Music is an art which draws inner feelings and experiences out, and in which feelings and experiences from without invade...
our inner beings. If this music comes from the otherness of a machine, how much more does the music involve "inner" contact with an "outer" world. Indeed it is this very non-humanity which gives the computer its most powerful attraction for modern composers. Just as chimes may produce rhythms under the influence of the wind which no human composer has dreamt of, so the computer, following its own "outer" logic, can create sounds and sequences of sounds never envisaged before. And yet the computer has no will of its own—it is a commonplace that computers can only do what they are programmed to do. The composer is the programmer also, and so prime mover in the computer's exposition of new sound-worlds. There is a continual dialectic of inner impulse translated into outer, and now independent, logic in the computer's generation of a new sound-world, returning as new inner experience for the composer. Such a dialectic has been a part of composition for centuries—composers have worked at piano or harpsichord keyboards—but on the one hand the dimensions of the sound-world offered by a computer are so much more vast, and on the other hand the means of controlling the machine, of communicating the composer's impulse, are so much more complicated. Thus a vast area of endeavou' has grown up in the last couple of decades, on the one hand to expand the dimensions of what is possible in sound creation and manipulation by computer, and on the other hand to facilitate control of computer equipment by musicians.

What of the musicologist, the scholar who is interested not in the production of new music but in the explanation of existing music? She or he looks to the one side and sees scholars of literature performing studies of authorship, style or other analyses by computer on bodies of text, and to the other observes the fecund and exciting world of computer music described above. Yet computer-assisted studies in musicology are still few and far between. At the recent joint conference in the UK of the Royal Musical Association and the Society for Music Analysis, I was aware of only one paper in which a computer had been used in the actual research rather than simply in the production of the paper. This was a study in which a computer was used in the recording and analysis of performance data by measuring the timing and speed of key presses on a piano (Clarke: 1993). This use of the computer followed a paradigm from natural science—the computer being used principally for data capture—rather than the paradigms of the humanities. Why is it that the musicologist's reaction to computers is so often one of frustration rather than the fascination composers enjoy?

1 It is this which distinguishes computers from dedicated music technology such as synthesisers: the latter have means of control which are simpler (e.g. sliders) and more familiar (e.g. keyboards) but the possible sound-worlds are restricted by the assumptions of the manufacturers. The computer, as an "ideal processing machine" is in principle totally unrestricted.
In 1970, early days in the history of computing, Harry Lincoln published a report on “the current state of music research and the computer”. While not brushing aside problems of representation, programming etc., the general tone is optimistic, and Lincoln concludes ‘It is to be hoped that the future will see the acceptance of one music representation as a lingua franca; the development of widely usable programs with a central clearing house for such programs; and the development of data banks of encoded music scores, thematic indices of various repertories, and other information useful to the music researcher.’ (Lincoln: 1970, p. 36). In 1974 he published a second report in which the tone has changed: ‘Computer applications to music research have not proceeded at the pace (or with the success) predicted by optimists a few years ago.’ (Lincoln: 1974, p. 285). Lincoln identifies the continuing problems of the computational representation of musical information and musical processes as the principal reason for this. Interestingly, or perhaps depressingly, the same problems are evident also in the much more recent ‘reflections’ by Eleanor Selfridge-Field (1990). The only one of Lincoln’s hopes from 1970 to have been achieved is that bibliographic data in musicology is available on-line and there are limited successes also in the field of data banks of music.² There certainly is not a single representation which has become a lingua franca, though dialects of DARMS continue to be used more than any other scheme, and the only widely-used programs are commercial music notation programs, though these are generally used only for production of fair copy because they cannot usually be integrated with any analytical or archival software.³ Contrast this with the situation in the world of computer composition and synthesis: MIDI is a widely-used representational standard and there are standard formats for digital audio; there is not a single clearing house, but the modern phenomenon of wide-area networks and ftp servers means that a lot of software is readily available, and some individual programs, such as Barry Vercoe’s Csound, have become standard tools; data banks of music do not exist to any great extent, but these are not important for composers—what does exist is a lively exchange of information via computer networks.

Part of the reason for the failure of progress in computer-aided musicology is economic, of course. The disadvantage of the computers’ generality is that much programming is required to make them do a specific task, and progress is best

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² Notably the Essen collection of folksongs (see Schaffrath: 1992). Also the Centre for Computer Assisted Research in the Humanities (CCARH) at Menlo Park, California, is soon to release datasets of Bach compositions (for information on CCARH see Hewlett & Selfridge-Field: 1985-).  
³ Leland Smith’s notation program Score inc., is a partial exception in this respect in that it can be loosely coupled with other software because it has well-defined input and output file formats. Also, the Essen project referred to above has a growing set of programs associated with it which are used in other places also.
made if a suitable program can be acquired from elsewhere. But musicologists are a small and not-very-lucrative market. Commercially available music software is directed at the home user and amateur pop musician. A number of programs which can display and print-out music notation are available, for example, but, as mentioned above, none of them can be easily interfaced to a database so that a musicologist might use them as a means of input and output. However, the economic argument is only part of the story—it applies in almost equal degree to the world of composition and yet that field is flushed with software. There are technical difficulties also, and these are principally the ones Lincoln identified back in 1974: questions of the representation of musical information and processes.

The "otherness" of the outer world of the computer is a positive benefit to the composer but, usually, a hindrance to the musicologist. The musicologist is interested not in unexpected outcomes but expected ones. She or he has some analytical task in mind, but for the computer to perform this task the inner conception must be given outer form. The inner conception might be quite precise, in the sense that there is no question in the mind of the musicologist whether or not the task has been properly performed, but that does not mean that it is clear. The translation of this task to outer, computational, form requires it to be broken down into components which themselves have corresponding outer formations. The problems in performing this sort of translation of musical tasks are two-fold: firstly the decomposition into components can be problematic; secondly there is not a set of components with pre-existing outer formulation on which to build.⁴

Selfridge-Field (1990) identifies similar problems, which she expresses in terms of precision and generalisation. On the one hand the precision of computer technology, rooted ultimately in the digital, on-off, nature of its design, tends to lead to a similar precision in explanations of music: the traditional "rules" of harmony and counterpoint are revised, refined and augmented. On the other hand the computer's precision is a sort of narrow-mindedness and results arise which are precise but musically meaningless because they lack the benefit of general musical intelligence. In the latter category she examines the results of "matching" melodic openings in a computer database. In previous research without the aid of a computer, she has found that a particular melodic pattern, traceable ultimately to the hymn tune *Lucis creator optimae*, occurs frequently in seventeenth-century Venetian instrumental music. A catalogue of sixteenth-century Italian madrigals

⁴ Contrast this with the situation in text-based studies where at the very least there is a well-defined computational representation for characters, moderately well-defined means of building representations of words from representations of characters, etc.
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has recently been published (Lincoln: 1988) with a computer-generated index formulated in such a way that it is a simple matter to find all the madrigals which begin with the same melodic pattern. However, Selfridge-Field finds only three of the resulting thirty-five matches to be acceptable. The computer has failed to perform the analytical task adequately because Selfridge-Field's inner conception of what constitutes a match and the outer formulation of the task as a simple search of the computer-generated index are not congruent.

In the twenty years since Lincoln's reports there certainly have been attempts to overcome these problems, and solutions appropriate to the tasks at hand have been arrived at. Furthermore, from the earliest days scholars have attempted also to generalise from these solutions to build the groundwork to facilitate other computer-based musicological studies, but this groundwork has been elusive. At first it seemed that all that was required was an agreed method of representing musical information in computational form. Then it became clear that formulating the tasks to be performed on that information is no easy matter. Now it is clear that even the nature of the information itself is at issue. From these endeavours emerges the nascent discipline of musical informatics. The term does not have wide currency in the English-speaking world. One speaks more frequently of computer applications in music or even of computational musicology, but what is involved is a genuinely novel area of study and not simply the application of computers to existing studies, as implied by the former term, and the latter term does not make clear whether what is meant is musicology by means of computation, or musicology which is itself computational. Selfridge-Field (1990, p. 306) aims to distinguish between 'musical informatics, in which the emphasis is on the method, and electronic musicology, in which the emphasis is on the content'. But musical informatics is far more than just method—it is only without "content" if that word connotes particular pieces of music rather than music in general. It is true that it is of little importance to musical informatics whether a piece under study is one particular piece rather than another, but just as historical musicology is meaningless without a general theory of music, implicit or explicit, in terms of which to formulate its conclusions, electronic musicology is fruitless without a theory of musical information to guide its operation.

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5 One can assume, also, that there are other acceptable matches which the search of the index failed to deliver.

6 A similar argument, presented in terms of ideal and real, perfect and imperfect, is included in Marsden & Pople: 1992.

7 It is current in Italy, where there is an Associazione di Informatica Musicale Italiana, but there it seems to be broad enough to encompass the use of computers in music in its generality. The term is also used in French.
Nevertheless, the discipline of musical informatics has clearly separable theoretical and applicative branches. On the theoretical side, the primary question is "What is the nature of musical information?", and the secondary question "What are the precise definitions of processes one wishes to perform with musical information?". These questions have no necessary reference to computer technology, and so relevant literature can be found in the well-established field of music theory and in the newer field of cognitive musicology. On the applicative side, there are studies concerned with the most effective way of making computer implementations of musical databases and processes. This study too has a history, but, as suggested above, it is only recently that it has been grounded in theoretical musical informatics.

As an illustration of what this theoretical discipline involves, consider again Selfridge-Field's task of finding matches with the *Lucis creator optime* melody in Lincoln's thematic index. The method of representation of melodic incipits in Lincoln's 'Thematic Locator Index' is as follows. 'The interval sequence of each incipit has been computed and printed using signed digits: an ascending second is +2, a descending second is −2, an ascending third is +3, and so on. Repeated notes are ignored.' (1988, p. XI) This results in a scheme in which ordering is clear and simple and in which transpositions of melodic patterns may be readily identified because it is the intervals between notes which are represented and not the notes themselves. While the notes change under transposition, the intervals do not.

![Fig. 1.- The *Lucis creator optime* motive as given by Selfridge-Field: 1990, p. 310](image)

Selfridge-Field gives the basic "motive", derived from the *Lucis* hymn, as in Figure 1. She then gives some qualifying description of the types of matches previously found in Venetian instrumental music: the motive 'is either set out in whole notes and used as a skeleton for contrasting motives in smaller note denominations or it is used as a head motive that is repeatedly used in imitation by other voices. In either case it appears with equal stress on all six notes and without immediate repetition of individual notes. It is also the dominant (sometimes the only) theme present.' (1990, p. 310).

The *Lucis* motive in Lincoln's representational scheme is "+2,+3,−2,−2,−2". It is a simple matter to look this up in the index and find the thirty-five incipits which start with these intervals. However, Selfridge-Field finds that all but
three of these ‘fail an intuitive test’ (1990, p. 310). Four of the “false” matches are discussed in her article. The first false match is a composition by S. Festa (Figure 2). This is considered false because its stress pattern implies a different melodic outline from the *Lucis* hymn. Particularly significant, presumably, is that the second G falls on a very weak beat, and so the six notes do not have the ‘equal stress’ Selfridge-Field requires in her gloss on the basic motive quoted above. Secondly, there is an immediate repetition of the first note here. This is of course hidden by Lincoln’s representation, which ignores repetitions, but Selfridge-Field recognises that ignoring repetition might be a necessary part of taking account of stress. To exclude cases like this where the stresses come in the wrong place, either stress patterns must be included in the representation, or the matching algorithm must have some way of computing stress patterns.

The latter is no easy matter, because, as Selfridge-Field points out, even if rhythmic information is included in the representation, it is not a reliable indicator of stress. Nevertheless it must be possible in principle—the fact that a musician can determine stress from music notation alone indicates that a mapping exists from the information contained in music notation (which does not include reliably explicit indications of stress) to stress patterns, though this mapping might depend on a lot of musical knowledge.

The former, to include stress patterns in representation schemes, is certainly possible. The simplest thing would be to add a special symbol to the representation of stressed notes. Lincoln’s scheme represents intervals and not notes, but we could still add a special symbol to his notation to indicate the position of stressed notes in the sequence of intervals. Let us use the symbol “[ ]” for this purpose. The Festa theme then becomes “[ +2 | +3 | −2 | −2 | −2 | ]”. This is clearly different from the *Lucis* theme, which becomes “[ +2 | +3 | −2 | −2 | −2 | ]”.

Note, however, that ordering of themes is now not so simple. Lincoln orders as one would expect, giving priority to the absolute size of intervals over their direction. Thus “+2, +3, +2,…” precedes the Festa theme, and “+2, +3, +3,…” succeeds the theme. How are stress symbols to fit in the order or priority? Does “[ +2 | +3 | −2 |…” come before the Festa theme or after it? Obviously if we are talking about a real computer database and not a printed

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8 This and the Arcadelt theme below have been re-transcribed into modern treble and bass clefs for ease of reading by those unfamiliar with the original C clefs.
catalogue, the question is less important because we can always ask the computer
to make a search, but if the database is to be organised or indexed in such a way
as to minimise the time taken by such searches, answers must be found to similar
questions.

Recall that Selfridge-Field admits as uses of the Lucis theme occasions when
it is 'used as a skeleton for ... motives in smaller note denominations'.9 A similar
concept is at work when she reduces the Festa theme to its 'simplest melodic
outline' (1990, p. 311), which is different from the Lucis theme. What she has
done is to remove the non-stressed notes from the melody, which would result,
in the representation suggested above, in the outline "| +2 | +2 | −3 |". This
can be computed from the full melody by adding together the intervals between
stress marks.10 The same logic means that in searching for matches with the
Lucis theme, a computer-aided analysis should also find themes whose opening
pattern of intervals could be reduced to that of the Lucis theme by addition of
intervals between stress marks. Thus the matching algorithm must be more than
a simple looking up in an index. Furthermore, there is no way that a test of every
single item in the database against the Lucis theme can be avoided unless the
interval between stressed notes is used in some way in the indexing or ordering.
Perhaps this information should be calculated whenever a melody is entered
in the database, and the reduced pattern of intervals stored in the database
also. Thus the representation of the Festa theme would have two parts and
look something like "| +2 | +3, −2 | −2 | −2 |: +2, +2, −3 |", where the colon
separates the representation of the actual melody from the representation of
the melodic outline. This could be indexed according to each part, and a search for
melodies which use the Lucis theme as a skeleton becomes once again a simple
matter of looking up the index. The "knowledge" about reduced interval patterns
has been taken out of the search algorithm and put into the representation. In
one sense this is preferable because it now means that the information is available
to other processes, but it does increase the space required for the representation.
The availability of the information to other processes could also be achieved with
an appropriately modular design of the software, so that the "extract-outline"
part of the algorithm is separated from the search, but there would remain a
common trade-off between speed and space.

Two developments of the ideas of stress pattern and melodic outline deserve
discussion. Firstly stress frequently exists on more than one level, and is strictly

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9 An example of this is discussed below.

10 But allowing for the curious arithmetic that 2 + 2 = 3 etc. because of musicians' tradition of
calling a single step in a scale a "second".
hierarchical (i.e. a stressed note at a higher level is also a stressed note at a lower level, but not vice versa). This could be represented either by using different symbols for different levels of stress or, perhaps better because it allows an infinite number of different levels of stress, using "||" for second-level stress, "|||" for third-level, etc. The Festa theme would then become "|| + 2 || + 3, -2 || - 2, -2 ||". Note, however, that this requires us to know the lowest (first) level of stress before beginning to encode. In some circumstances this is inconvenient or impossible (e.g. if a system is being used for composition and the entire piece does not exist as yet!). A solution to this is to represent not the points of stress but, by means of brackets, the spans between stressed notes. Under this scheme the Festa theme would be "[ +2 [ +3, -2 ]] [ -2, -2 ]".11

Secondly, the pitches which form the melodic outline are not necessarily those of the stressed notes (though, to be fair, in the sixteenth and seventeenth century they very often are). This is most clear in the case of appoggiaturas, which, like passing notes, are dissonant notes which resolve by step onto the following main note, but which, unlike passing notes, are stressed while the following main note is not. An example (from Mozart's string quartet in C major, K. 465) together with its melodic outline, is given in Figure 3. In bars two and four it is the G and A respectively which are stressed, but the main notes are F and G, as the harmony (not shown) makes clear. A solution would be to have another special symbol, e.g. "*", to indicate where the main note comes in each span. The Mozart theme would then be represented by "[* +2, +2, +3 ] [ −2 * −3 ] [ * +2, +2, +3 ] [ −2 * ]".12

Fig. 3. – a: the opening theme of the Allegro of Mozart's quartet in C major, K. 465. b: the melodic outline of that theme.

The matching algorithm must now add intervals between asterisks. The stress marks have become superfluous and we could dispense with them, which

11 A similar scheme, and its relation to real music, is discussed in Marsden: 1991.
12 This scheme is not unlike one proposed, for a different purpose, by Deutsch and Feroc: 1981.
means, of course, that we are no longer representing where the stresses come in the melody. This is a case of the "precision" issue identified by Selfridge-Field: we start with a concept of stress which is perfectly workable for musicians, but, on attempting to put the analytical process into computational form, we find that the concept needs more precise definition and becomes rather different. Secondly, it was pointed out above that it is no easy matter to infer stress patterns from music notation, though the notation of metre often at least gives a starting place. It is much less easy to infer which are the main notes—music notation rarely gives any help, and alternative interpretations are quite possible. A representation which includes indications of main notes is therefore a representation of an interpretation of the notation, but this may nevertheless be a more appropriate representation of the music than a representation of the notation alone. The notation is not the music—it must be read to become music, and reading always involves interpretation.¹³ But how are alternative interpretations, and indeed the process of interpretation itself, to be accommodated in a computational system? One’s interpretation of a piece might be different when searching for matches with the Lucis theme than when searching for matches with some other theme.

The other false matches Selfridge-Field discusses raise yet more issues. Her second case (by J. Arcadelt, Figure 4) fails on the same grounds as the first, and also because it is in a different mode (i.e. the semitones come between different degrees of the scale. The scale of the Lucis theme has a semitone between its third and fourth degrees; that of the Arcadelt theme has a semitone between the second and third degrees). Lincoln's representational scheme represents the number of scale-steps between notes without distinguishing between the size of these steps. A scheme which represented intervals by their size in number of semitones would distinguish clearly between the Lucis and Arcadelt themes: Lucis would be “+2, +3, −1, −2, −2”, the Arcadelt would be “+2, +3, −2, −1, −2”. But on other occasions we do want to ignore the exact size of intervals, and concentrate on scale steps alone. It is this which allows us to recognise the tune Frère Jacques in Mahler’s first symphony, despite its being presented in a minor

¹³ David Huron points out that any representation is also an interpretation, and discusses the consequences of this (1992, pp. 9–10 & 31–34).
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key. Thus besides the complex questions of interpretation outlined above, there are simple questions of precisely what information is to be included in a representation. The questions are simple, but finding general solutions is not. The representation of pitch, in particular, is a problematic area which has attracted a considerable amount of work. Similar work has also been published with respect to rhythm. Huron (1992) gives a discussion of the principles underlying representation schemes.

Selfridge-Field's third and fourth false matches are both rejected on the basis of context. In each case the melodic pattern is judged to arise because of internal factors, in one case contrapuntal in the other harmonic. The reasoning is presumably that these factors offer an explanation for, or were the motivation for, the pattern, and one cannot therefore explain the pattern by reference to the Lucis theme or ascribe to the composer any intention to reuse this theme. To model this analytical process a computer would not only have to have a rich representation of the melodic pattern's context (which I suspect is a realistic possibility in the current state of technology) but also be capable of carrying out a very complex reasoning process (which I suspect is not a realistic possibility). There will always remain analytical tasks which the musicologist must perform herself. This is not to say, of course, that computers are useless—in a case like this it is quite reasonable that a computer might produce a first set of possible matches which the musicologist then prunes on the basis of the type of reasoning from context used here.

Finally, it is instructive to examine a case which Selfridge-Field considers to be a legitimate match, taken from her earlier study of Venetian instrumental music (1975, p. 203). This is the opening of a violin sonata by Albinoni, shown in Figure 5. How is the Lucis theme to be matched with this melody? The first four notes of the theme are easily found to correspond to the first note of each of bars one to four, i.e. the stressed notes. Up to this point a representation showing simple metrical stress, such as suggested above, would be sufficient for the match to be discovered. After this point, however, things become more complicated. The first notes of the following two bars are simply continuations of notes from the previous bars, and so cannot be stressed. I suspect, however, that a violinist would stress the final B in bar four, and the A and final G sharp in bar five, by manipulation of timing, volume and/or articulation. The stresses in the continuo part, however, would be on the C sharp and B in bar five, out of synchronisation with the violin but conforming to the pattern of the metre. Furthermore, a

musicologist would claim that the melodic outline here is as shown in Figure 5b. The C sharp which underlies the first half of bar four is not consonant with the harmony indicated by the figures #4/2 in the middle of the bar, but the B, which is consonant with this harmony and which replaces the C sharp as the underlying note, does not appear on the surface of the music until the end of the bar. Even more clearly, the B in bar five which is tied over from the previous bar is dissonant with the harmony at this point, and resolves to the following A. The interpretation at this point, as is usual for such suspension configurations, is that the suspended B delays the arrival of the A which, in the melodic outline, occurs at the beginning of the bar in synchrony with the harmony with which it is consonant. (A related pattern occurs later in the bar with the A and G sharp.) Furthermore, while the melodic outline is not entirely ‘set out in whole notes [semibreves]’ as Selfridge-Field would hope from her comments on uses of the Lucis theme quoted above, one can argue that it has ‘equal stress on all six notes’ despite the change in durations. Albinoni presents a smooth and rather clever transition from one harmony per bar at the opening to four harmonies per bar by bar five. In bar one there is simply one bass note and one harmony. In bar two

Fig. 5. – a: the opening of Albinoni violin sonata (Roger no. 3) [Selfridge-Field: 1975, p. 203]. b: its melodic outline.
the bass note changes register but the harmony remains the same. In bar three there are two bass notes and two harmonies. In bar four there is first a repetition of the same bass note with the same harmony (similar to bar two at twice the speed, though the violin part does suggest the addition of an extra note which would change the harmony), then there is a change of harmony over the same bass note, and finally a new harmony and bass note. The whole bar thus contains three harmonies and three bass notes, but not in synchrony with each other so that something happens on each of the four crotchet beats. Finally in bar five we have four bass notes and four distinct harmonies. (The number 6 under the rest simply indicates the resolution of the dissonant B and does not indicate a new harmony.) One could argue, therefore, that, since the music moves faster as it progresses, the stresses on each minim beat in bars four and five are equal to the stresses on each semibreve beat at the opening.

It is unrealistic to expect a computer system to routinely pursue reasoning of this sophistication. The realistic goals of musical informatics are the definition and systematisation of different types of musical information, implementation of systems for their entry and retrieval, and the definition and implementation in robust and reusable form of common musical processes, of which melodic matching might be one but there are many other simpler processes which should be considered also, e.g. part extraction, merging, segmentation, concatenation, etc. The human musicologist will always need to exercise her or his judgement, so methods must be sought also for systems to seek and use such judgements when appropriate. The field is an exciting one, and one which has the advantage that when the soullessness of the computer becomes irritating one can escape to the beauty of the musical materials!

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