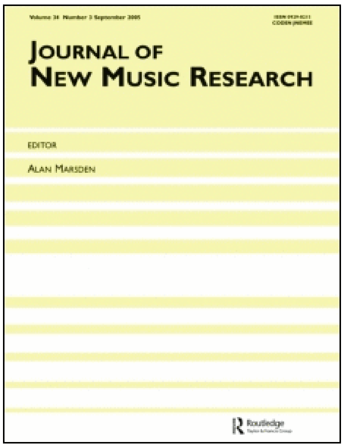

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MIDIM-duplication of a central-Javanese sound concept

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MIDIM-Duplication of a Central-Javanese Sound Concept

Jos Janssen and Heinerich Kaegi

ABSTRACT

One of the many practical applications of the MIDIM-system in the last few years has been *the duplication of existing sound families*, in particular those of musical and speech sounds. In the first part of this article we will define the concept of a sound duplication and show a method by which means duplications may be found. This method is particularly suitable for the MIDIM/VOSIM-system. In the second part an application of this method is shown for the instrumental concept *Gender* drawn from the *Central-javanese Karawitan.* We shall also concern ourselves with a number of other concepts from this music culture.

PART I - MIDIM SOUND DUPLICATIONS

Apart from continual investigations into western instruments a few members of the MIDIM-group have devoted themselves to sound duplications of non-western instruments[0]), in particular Javanese instruments. In our article we shall discuss this work. In part I what exactly sound duplication means is formally described and a method shall be shown by which MIDIM-duplications may be found.

1 WHAT IS A SOUND DUPLICATION?

A sound duplication is a bundle of rules defining a set of synthetically generatable sound events, which are associated with an existing sound concept.[1]) Each sound event of the duplication corresponds ideally to a sound event which belongs to this existing concept. Duplications are formulated by means of a

[0]) Already in 1978 K. Samkopf did investigations on Chinese tempelblocks which he used in his composition Etude nr. 1 (1979); in 1983/84 Dr. Kaegi analyzed the alphabet of the Central-javanese Kendhang Ciblon (Jav. drum) which was the starting point for his composition Dialogue for Kendhang and computer (1984); in 1983/84 Jos Janssen did an experiment using his Gender duplications in the context of a classical Javanese composition (Subakastawa Pl.6 for Gamelan Gadhon and computer). See also composition list pag. 182. (All documentation concerning the duplications are available in the archives of the MIDIM-group).

[1]) The duplication of sounds does not have to be limited to natural sounds. It would be quite possible to make a MIDIM-duplication of the coloratura of the KÖNIGIN DER NACHT, synthesized by means of the sound synthesis system CHANT of IRCAM in Paris (see Rodet, 1984).

formal language (to which soft- and hard-ware designs belong), in particular formal languages which are suitable for sound-synthesis, such as in our case the MIDIM-language.

A sound duplication in our sense describes thus *collections of sounds* (W. Kaegi calls this concept-duplication) *and should not be confused with the duplication of unrelated sound events* (event-duplication).[2])

2 WHY MAKE MIDIM SOUND DUPLICATIONS?

Before giving a formal definition of what a MIDIM-duplication is, we shall mention a few important and meaningful scientific and artistic applications of it:

1. Duplications show the expressive power of the MIDIM-system, because the truth or falsity of our duplicated sounds is easily tested by comparing them with the originals. (Kaegi, 1986, p. 101) On the other side via duplications new functions (which have an interpretation in our music culture) may be found in order to expand the existing function table.

2. Every MIDIM-duplication means a formalization of the desired concept (see part II) thus an increase in our knowledge of this concept.

3. The formalization of existing sound concepts (which we have already mentioned) makes it possible to compare these concepts in a formal way. (Think about the comparison of musical and speech sound concepts stemming from one and the same culture. See Kaegi, 1986, p. 130 and the composition list: DIALOGUE, Goodman, 1986, p. 169).

4. A musician can use duplications as a starting point in order to derive sound families. (In MIDIM-compositions for computer and soloist this procedure is often applied, for example in CONSOLATIONS and RITOURNELLES of W. Kaegi. See composition list, Goodman, 1986, p. 182).

[2]) That from the beginning we concerned ourselves with sound concepts (signs) and not with instances (in other words with signals), was already apparent in "Das Problem der mentalen..., Kaegi, 1975" from which we quote the following:
"Es wurde vielmehr von Beginn an unterstellt, dass nicht von Signalen bezw. Signalfunktionen, sondern von Zeichen auszugehen und das Problem in umgekehrter Richtung anzugehen sei. Nämlich durch den Versuch, von musikalischen Zeichen auszugehen und zu einer metrischen Beschreibung der Zeichen in einem n-dimensionalen physikalischen Raum vorzustossen". (See also Kaegi, MIDIM, 1986, p. 131).

5. Users of the system learn via the construction of duplications to listen to and to abstract elements from the sounds they hear and then to translate these elements into the MIDIM-language (See Goodman, 1986). This opens the way to the formalization of imaginary sounds (e.g. in artistic work).

6. Duplications make possible the development and testing of pattern recognition algorithms, which fit with the MIDIM-functions.

In what follows below we shall show by which methods duplications may be found.

3 DEFINITIONS AND ASSUMPTIONS

We introduce first the set MC which is *the Music Culture under consideration* and which contains on the one hand *the set* U (universe of discourse) of *all musical sound events of* MC and on the other hand all *expressions, concepts, definitions* etc. ("the context"), that are related to the sounds. K is a particular sound concept within the music culture MC. We call this concept: *the descriptive concept* (Kaegi, 86, p. 101).

The *extension* of K, which we call K_e is *the set of all sound events or instances* i_K, which belong to the descriptive concept K. K_e is a subset of U.
Thus $i_K \in K_e \quad K_e \subset U$.

In analogy to this, in the MIDIM-language the *predicator P is a MIDIM sound concept,* which we call the M-concept. The *extension* of P, which we call P_e is *the set of MIDIM sound events or instances* $i_P \in P_e$, selected from out the VOSIM-matrix V^*. The instances are thus (sequences of) VOSIM-vectors.
Thus $i_p \in P_e \quad P_e \subset V^*$.[3])

The *intension* of P, which we call P_i is *a bundle of MIDIM-functions* (taken from out the function tables and substituted into a MIDIM-vector $\vec{m}_0$, see Kaegi, p. 93), whose *course of values is the extension* P_e (Carnap, 1947).

Descriptive concept K (predicate) —<
- INTENSION: properties
- EXTENSION: K_e, which is the set of all sound events i_K, which satisfy the properties.

[3]) We tacitly assume here that V^* contains all sound concepts from U, in other words the music culture MC falls within the "field of application" of the MIDIM-language. This implies at the same time that the music culture MC belongs to the Indo-european music culture. See Kaegi, 1986. p. 101.

MIDIM sound concept P (predicator)
- INTENSION: P_i, which is a bundle of MIDIM-functions (substituted into a $\vec{m}_0$-vector).
- EXTENSION: P_e, which is the set of all MIDIM sound events i_p (sequences of VOSIM-vectors), satisfying these functions.

The above scheme is now given for a Böhm clarinet (b-flat; played in the french manner):

Descriptive Concept: Böhm clarinet
- INTENSION: property to be a Böhm clarinet sound.
- EXTENSION: the set of all sounds produced when performing on a Böhm clarinet.

MIDIM-concept: Böhm clarinet predicator
- INTENSION: The bundle of MIDIM-functions belonging to this predicator.
- EXTENSION: The set of all VOSIM-sounds supposed to be accepted by listeners as Böhm clarinet sounds.

The MIDIM-formalization of this descriptive concept is shown by Kaegi (1986) p. 126/7.

We now call P_i *a duplication of* K *if and only if within all pairs* (i_p, i_K) *of corresponding instances,* i_P *and* i_K *cannot be distinguished in sound.*
A formal (e.g. MIDIM-)concept is thus accepted as being a duplication *by means of experimentation.* The design of the appropriate experiments will be discussed in par. 6.7.

4 FROM AN INTENSION TO AN EXTENSION AND VICE VERSA

In the MIDIM-language a predicator is an expression where at most the prosodic parameters T′, DUR, and At are λ-tied variables. The transition from an intension P_i to a particular sound event, or instance i_p in the MIDIM-language takes place in the formulization of a descriptor and λ-elimination of the prosodic parameters T′, DUR, and At. P_e can now be calculated by a repetition of this procedure, whereby the prosodic parameters become varied over their domains. One can thus say that the MIDIM-language allocates to the intension P_i the extension P_e.

MIDIM-language: $P_i \rightarrow P_e$

As is known from logic (Carnap, 1947) *every intension uniquely determines an extension. It is impossible to move in the opposite direction namely from an extension to its primitive intension without meta-information.* If we know for example only a set of VOSIM-vectors, *without any further information* about the MIDIM-language, then it is impossible to find the bundle of MIDIM-functions which generated these VOSIM-vectors. Information about the MIDIM-language and its functions is required in order to rediscover the intension.[4])

$$P_e + \text{meta-information} \rightarrow P_i$$

This is one of the most important problems of pattern recognition. The discovery of a pattern from a signal always calls for knowledge (meta-information) concerning the pattern sought. (Banerij, 1969).

5 SEEKING A DUPLICATION THEORETICALLY

Even though the instances i_p of a duplication sound like the corresponding instances i_K of the descriptive concept K, they are actually *not* in most of the cases *physically identical,* i.e. they have not the same signal function.[5])

Thus $i_K \neq i_p$ (physically)

Thus seeking a duplicate necessitates not only the step from the extension to the intension of the M-concept $P_e \rightarrow P_i$ but also the steps from the descriptive extension to the extension of the M-concept $K_e \rightarrow P_e$. The signal functions of the descriptive extension K_e could first be reduced to VOSIM-vectors (with VOSIM-signal functions as an intermediate stage) from which we should have

[4]) Experiments have been performed in order to calculate from an arbitrary sequence of VOSIM-vectors the corresponding MIDIM-vectors. In most of the cases this appeaeed to be impossible. We note here that the set of all possible MIDIM-functions was known in the form of meta-information.
When mapping MIDIM-vectors onto VOSIM-vectors one actually changes languages; so we may call the meta-information which is necessary in order to proceed backwards from the VOSIM to the MIDIM-language "extra-linguistic information within the VOSIM-language".

[5]) For simplicity the differences existing between the concepts "VOSIM-vector", "signal" of a sound, "perception" and "cognitive mapping of a sound" have been ignored. That these differences are in principle quite important is shown by the fact that for auditors instances may sound identical, while not having the same signal functions. A natural signal contains much "non-relevant information" or redundancy, which, when eliminated, does not effect the auditory experience. Kaegi has shown this in "A new approach to ..., 1972". The idea of a minimum description is based upon this. (MIDIM = MInimal DescrIption of Music).

to determine (with the help of the necessary meta-information) the appropriate bundle of M-functions P_i.[6])

The step $K_e \rightarrow P_e$ may in physics be summarized as the mapping of empirical data onto the most appropriate function. This is called *curve fitting* (see par. 6.6). Meta-information is once more needed for this transition. (Imagine for example statistical algorithms of abstractors, selecting the data which is needed for the approximations.)

Curve fitting: K_e + meta-information $\rightarrow P_e$

In practise one does not in most cases know *all* elements of K_e but simply a selection. For this reason it is necessary to interpolate between the instances in order to fill in those missing. Also the choice of the type of interpolation to be used depends upon the meta-information. (For example: if we know simply two points it is possible to connect them with many types of different functions. Which function we should choose finally depends on the meta-information.)

By preference the step from the descriptive extension to the intension of the M-concept $K_e \rightarrow P_i$ is not performed via P_e but by constructing *a spectral space* R_s *within which the descriptive instances* i_K *are fit to the MIDIM-functions.* We obtain then the following analysis-chain:

Analysis: $K_e \rightarrow R_s \rightarrow P_i$

In the following paragraphs these analysis-chains are dealt with in detail. Part II of this article shows an example of a duplication of the descriptive concept *GENDER* (metallophone from out the *Gamelan)*[7]) which belongs to the music culture (MC) of *Central-Java.* In order to prepare for this we shall have a brief glance at this concept in par. 6.

6 SEEKING A MIDIM-DUPLICATION IN PRACTISE

The above logical foundation of the concept-duplication could be formulated in *any* powerful sound-synthesis language. We will limit ourselves to MIDIM-terminology, because on the one hand the language has proven to be extremely powerful and on the other hand because a large number of duplications have been realized with the MIDIM-system. Moreover certain parts of the analysis-chains were formalized and effectivized while others were as yet still performed by hand. How we proceeded in practise is shown in Fig. 1.

[6]) There have been made attempts to map an arbitrary signal into a VOSIM-signal but simple algorithms for this could not be found.

[7]) A 'GAMELAN' is a collection of bronze percussion instruments and diverse aerophones, cordophones and membraphones.

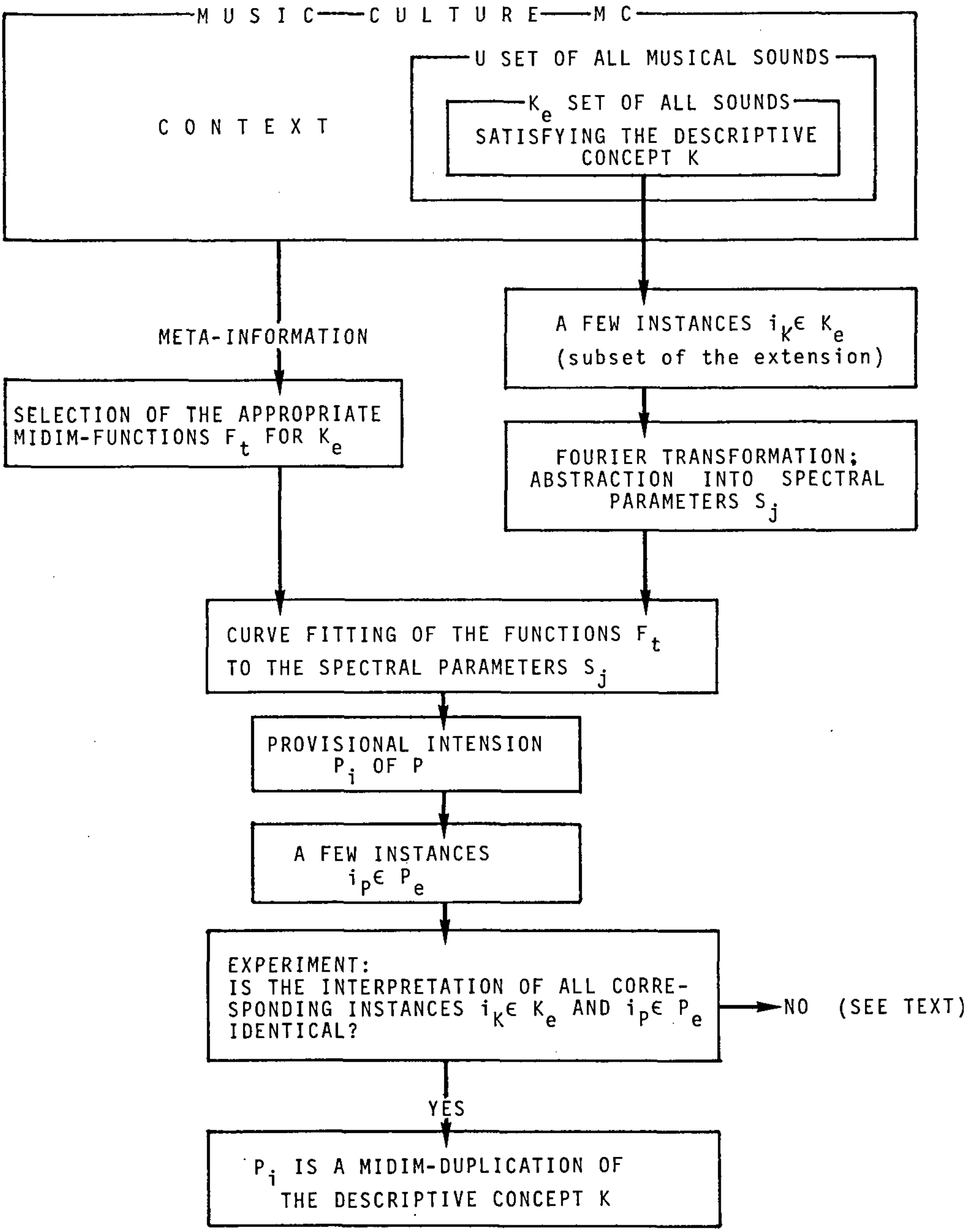


Figure 1. Scheme for determination of a MIDIM-duplication.

6.1 Concept definition and acquiring knowledge

The first step towards a duplication is the definition of the desired descriptive concept K. For this *knowledge concerning concept K* and *the context* is needed; knowledge in the sense that it is possible *to judge whether or not any arbitrary element of U belongs to* K_e. Our concept must thus have a *clear* and *testable* meaning within the music culture (MC) to which it belongs. Let us take as an example of this the concept G: "Gender sound" which belongs to the Central-javanese Karawitan. We are *not* free to decide arbitrarily which sounds (instances) belong to this concept, because it has a very specific meaning deeply anchored in the Central-javanese music culture. We must ask Javanese musicians which sounds are to be considered Gender sounds. The clearest answer are the sounds themselves: the masters of Gender performance can show us by playing their instrument what a Gender sound is and then we become aware that there is an *unbreakable marriage between instrument, performer and the music culture* which has given birth to them (something which is often forgotten. This is also the reason we use the word *Karawitan* in this article in place of the term *Gamelan* which is more familiar in the west. Gamelan indicates only the instruments, while Karawitan designates the whole music culture.). It appears as well that musical concepts are sharply determined, although it is not always possible to describe them in colloquial language. *The musicians are able to show precisely what does and what does not belong to a concept.*[8]) See appendix I.

The choice of sound concepts for duplication which are readily testable is of the essence. On the one hand the duplication is made clearly testable by this (this does not for example hold for imaginary sounds), while on the other hand in this way *the functions used for the description are given a meaning within the music culture and are thus not anymore foundated on a purely physical basis.* Only when these conditions have been satisfied for a large number of very different families of duplications may we assert that our sound-synthesis language can give a formal description of the sound world in a music culture.

6.2 Registration of instances

Proceeding from a clearly testable descriptive concept K, we collect a number of instances $i_K \in K_e$, which together form the subset K_G of K_e. These *registrated instances* are stored on tape (or directly in the computer). For a registration it is essential that one after the other of the prosodic parameters T′, DUR, or At vary, while the other two remain constant. The instances can then be divided over the three sub-sets $K_G(T')$, $K_G(DUR)$, $K_G(At)$.[9]) (Holding for the MIDIM8X standard predicator; see Kaegi, 1986, MIDIM, p. 126).

[8]) The most sharply testable sound concepts are to be found in natural languages, because they are based entirely upon common sense (within a culture). Whats more, everyone can speak but not everyone can make music.

[9]) We assume here that the prosodic variables are not correlated. In practise one chooses configurations which have the most influence upon the sound.

6.3 Fourier transform

First fourier transform is applied to the registrations by means of effective algorithms performed by a computer and *careful listening.* (Kaegi calls this his "personal fourier analyzer")[10]) Fourier transform *does not change the signal information but only the representation of this information.* Application of fourier transform is based upon the assumption that the ear performs fourier transformation and that fourier representation is thus better able to reproduce a sound experience. In *fast fourier transform* (FFT) the signal is divided into small time segments and the spectrum is calculated per segment. Next the calculated data is mapped into a 3-dimensional space spent up by the axes time, frequency and amplitude of the coefficients, which is called *the running spectrum.*[11]) A clear representation of this as well as the interpretation which follows obliges us to apply *data reduction by abstracting certain tendencies by means of abstractors.* The so-called *peak-tracking abstractor* which we often applied connects the amplitude maxima (of the fourier coefficients) in the 3-dimensional space described in slices of either *constant time,* or *constant frequency* or eventually *a constant frequency band.* The peak tracks which result can be clearly plotted in a pseudo-3-dimensional representation (which is a projection of the 3-dimensional spectral space on an appropriate plane). The plots are abstracts. For convenience we call them "the spectra".

6.4 Division into MIDIM-segments

The MIDIM-language proceeds from *four segments* S_i in time. We seek thus in the spectral information an appropriate time segmentation. Therefore each peak-track abstracted has to be divided over the four desired segments. For this reason within a particular time segment a "constant deportment"[12]) in the peak-tracks is sought as well as in the amplitude envelope of the whole signal. From all segments the final MIDIM-segmentation is chosen and the time-durations of the segments S_i determined.[13]) A good example of a possible segmentation method is described by van Berkel, p. 241.

[10]) One can scan the spectrum by listening to sounds sent through filters, whereby the transmitted amplitude is read upon a dB-meter. W. Kaegi calls this "the poor persons fourier analysis". It should be noted that scientists tend to turn their noses up at this method as they consider it unscientific. They have the tendancy to prefer to represent their results pictorially.

[11]) The sampling rate for a digital signal representation determines the highest analyzable frequency, the "window width", represented in time the lowest frequency.

[12]) With constant deportment per segment we mean that the signal can be described (approximately) by a MIDIM-function of which the coefficients are not yet determined. For example: the constant behavior could be that the amplitude progresses linearly, so it can be described by a linear equation. The gradient is actually not yet known and is not determined until a statistical approximation takes place.

[13]) There are various methods for segmenting the signal. Strong changements in the envelope contour of the whole signal or of the peak-tracks (and eventually in the frequency changements of the peak-tracks) can be discovered by determining the derivative. The maxima in the derivative then give possible break-points.

Comparing the instances taken from the subset $K_G(DUR)$ (in which DUR varies while At and T′ remain constant) shows us which segment S is dependent upon DUR (one calls this segment A) and which value v in the M-concept C′(v) is thus applicable (Kaegi 1986, p. 116). From this point per segment S_i the whole analysis is performed.

6.5 Representation of the instances in the spectral space R_S

For the following steps we introduce the so-called spectral parameters s_j with $j = 1$ to n_j. We assume that n_j parameters (over one segment) are capable of characterizing a peak-track. For the description of the peak-tracks (given by the fourier transform and abstraction) by means of these parameters data-reduction (averaging) is applied which is dependent upon the type of spectral parameters which we have at our disposal. Although one can, if desired, introduce other spectral parameters, we make use of s_1 for the frequency f, s_2 for the amplitude a, s_3 for the amplitude changement Δa and assume a linear interpolation between a and $a + \Delta a$. (If the peak-track would shift in frequency as well over the segment then one would need to introduce a parameter Δf). In Fig. 2 a theoretical peak-track is shown. The original peak-track, from which the track shown is derived is left out for clarity.

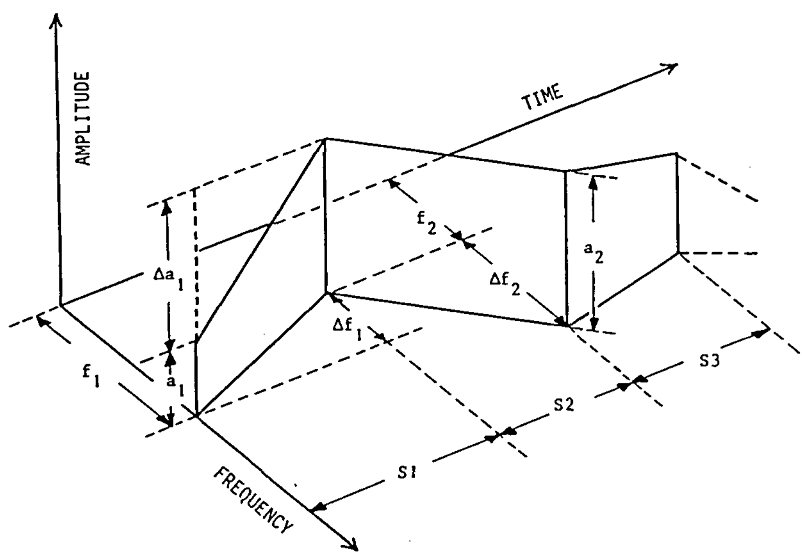


Figure 2. A theoretical peak-track (over three segments) described by means of the spectral parameters f, Δf, a, Δa in a 3-dimensional spectral representation.

Since by application of fourier transform and abstraction for each instance $(i_K)_m \in K_G$ (we index the instances with m) a series of peak-tracks (per segment) is produced, we can now assign to each instance various series of spectral parameters, namely:

$$(s_1, \ldots\ldots, s_{n_j})_h$$

The index h shows to which peak-track the parameters belong and runs from h=1 until n_h. (There are thus exactly n_h peak-tracks abstracted). Each instance $(i_K)_m$ can, as is known, be characterized by means of three constants $(c_{T'}, c_{DUR}, c_{At})_m$ which stand for the prosodic parameters T', DUR and At.[14]) We now construct a linear space R_s ("spectral space"), by means of the prosodic parameters and the spectral parameters, namely, T', DUR, At, $s_1,\ldots,s_{n_j}$ (dimension $n_j + 3$). With the spectral parameters which we have described and used f, a, Δa, our linear space R_s contains the coordinates (T', DUR, At, f, a, Δa). To each instance within this space there can be assigned n_h points. All instances from out K_G together thus form in R_s *a point-cloud.*

If we look now not from the standpoint of the registered instance K_G but from the standpoint of the MIDIM-language into the space R_s, than we see that to each instance $i_p \in P_e$ there *also correspond points* (again per segment). *Each MIDIM-function or product of functions (intension) from the function tables* (Kaegi, 1986, p. 94) *describes a set of VOSIM-vectors (extension), which one can conceive as a point-cloud in* R_s. *Finding a duplication thus comes close to finding the intension of a MIDIM point-cloud which fits best with the point-cloud of the instance* $i_K \in K_G$. This procedure has been called earlier by us *curve fitting.*

[14]) This assertion assumes that the prosodic parameters are already known in an extensional form. How do we know actually what pitch corresponds to an arbitrary instance? There are techniques for determining the fundamental via spectral analysis (F0-tracking) but in most cases this is not necessary because we have information taken from the context. If we record a piano, for example, then the pianist can tell us exactly which note was played, imagine the chamber tone a', then we know according to tuning standards that the fundamental equals 440 Hz, from which $T'=1/F_1$ can be directly calculated. The investigation of non-western sounds is more problematic. The tunings are often not a priori (extensionally) known or are even determined within an area, instrument or orchestra. In anticipation of this problem Jos Janssen began by measuring first (at the start of his investigations into Javanese sounds) the frequency values corresponding to the various Javanese tunings and instruments, which served as the reference standards. This shall be shown in Part II, par. 2. From the contextual givens, namely the pitch name within Javanese culture (and the name of the tuning and instrument which are used as references) T' can be directly determined. The functions ϕ_3 and ϕ_1 in the MIDIM-system, resolve this problem for western music because they connect respectively the pitch/octave names and subdivision with the pitch-frequency and the pitch-duration (in fractions) and metronome with the time-duration. The parameter At gives few problems because it is easily measurable (dB-meter) and is not of importance until we wish to study the relative amplitude differences between various pitches.

6.6 Curve fitting

Fitting the MIDIM point-cloud to the point-cloud of the instances i_K must result in the following concrete information concerning:

a) The indexes t of the MIDIM-functions F_t (taken from the function tables) which are appropriate for the descriptive concept K.
Through the indexes we find the λ-tied variables and their actual domains.[15])

b) The numerical values of all parameters (within the above functions) which are as yet not eliminated (with the exception of the prosodic parameters).

In order to clarify this we will give an example: the point-cloud which belongs to our Karawitan concept "Gender sound" appears to be best approximated by means of the function F_1: $T = q(T' + Of)/N$ for the reason that T is linearly dependent upon T'. In step a) our analysis system gives us thus the function index $t = 1$. Still unknown are the particular constants for q, Of and N (and all VOSIM-variables tied by functions not discussed here). In step b) the system must give us the values for q, Of and N which fit best. (We shall return to this in Part II).

The information desired cannot be abstracted from the signal information without meta-information (as shown in paragraph 5). Even if we know the basic set of functions (the function tables of the MIDIM-language) in the form of meta-information discovering the specific functions (point a) is in practise extremely involved. In contrast to this if the function rules of suitable fitting functions are known by means of meta-information then the procedure becomes drastically simplified and one can make use of the conventional approximation techniques.[16]) In this case as well a rather large number of instances is necessary (as an illustration: for a fit to a polynomial of degree n one needs at least n+1 points). One prefers to have a small number of instances because working one's way from a registration to the spectral parameters is rather cumbersome. *For these reasons gathering meta-information is of essential importance.* (See the branching to the left in Fig. 1). If we should desire that the analysis system itself would interpret the meta-information (often intensional), then the system must contain a very refined library of sound classes formulated within the MIDIM-

[15]) For simplicity the role played by the domains in seeking a duplication has not been dealt with in this article. Just as in the general MIDIM-theory (Kaegi, 1986) the problem of the domains (with their musical interpretation) is very involved.

[16]) Concerning this widely known problem there exist many publications. We indicate here Ludwig 1969. The best known algorithm is based upon the chi-square-criterium.

language. In the case that our library would contain the concept "Metallophone" then from the meta-expression "a Gender is a Metallophone" the system will "know" which basic MIDIM-functions will describe the Gender sound and only the missing coefficients would have to be abstracted from the instances. (Kaegi 1986, p. 121). There are many differing types of meta-expressions comparable to the one above from which it is possible to derive the necessary MIDIM-functions for the duplication of an instrument. (One does not necessarily need to know the sound in order to apply this procedure. One can ascertain from *the image* of a key-board for example that the pitches will be fixed or from that of large and small instruments (such as an alp-horn or a piccolo) that they shall resp. produce low and high sounds. Naturally previous knowledge is needed).

6.7 The testing experiment

Following our scheme (Fig. 1) we arrived at *a provisional intension* P_i. In order to test our analysis-chain we generate a number of *representative instances* i_p and perform an experiment *in order to investigate whether or not our provisional predicator can be called a duplication of our descriptive concept within the MIDIM-language.* (The condition that the concept must be clearly testable has been earlier stated by us). The experiment can be performed in many different ways, of which we mention three:

1) We let *musicians from the music culture* (MC) listen to the instances and ask if it holds for all i_p that: i_p belongs to K.

2) We let *an arbitrary test person* listen to the pair (i_p, i_K) and ask if the instances are similar in sound (similarity test, see Kruskal, 1964,[17]).

3) One performs spectral analysis and abstractions upon i_K and i_p and compares the corresponding spectra. (These tests are necessary if we should wish to use automatic trial-and-error techniques within an extended and effectivized analysis system.)

If our experiment is negative, then there are numerous methods in order to optimalize P_i. Indications for this are given by test persons and analysis data.

The above description shows how in the last few years many MIDIM-formalizations were arrived at. The quality of these duplications (which are considered as minimum descriptions) have proven on a large scale the enormous power of the MIDIM/VOSIM-system.

[17]) The Kruskal method was used often by Kaegi and Tempelaars in the past (Kaegi, A new approach..., 1972; Tempelaars, Testing elements..., 1973).

PART II - MIDIM-DUPLICATIONS OF THE CENTRAL-JAVANESE INSTRUMENT GENDER

In the second part of this article the results of the analysis method described will be shown for the *Central-javanese* instrument *Gender.* In order to give the reader a general overview of this non-western instrument there follows first a short description (a few important points of "the context"). That the extensional representation of pitch in frequencies is the first step towards a MIDIM-formulization is discussed in paragraph 2 together with an explication of a number of Javanese tuning systems. Afterwards we give a description of various Gender families. The description of the registered instances $i_K \in K_G$ and the concept K will then be the next stage in working towards a systematic presentation of the MIDIM-duplications of the Gender.

1 THE GENDER: AN INITIAL DESCRIPTION

The *Gender* is an *Indonesian metallophone,* which appears in the *Balinese* and *Javanese Gamelan.*[1]) The *Central-javanese* Gender, to which we shall limit ourselves in this article, contains generally 13 or 14 bronze keys which hang horizontally beside each other in a wooden frame by means of a cord. The height of the frame is ca. 40 to 45 cm and the length ca. 1 m, while the width runs from 12 to 16 cm. These sizes hold for the average Gender (usually *Gender Barung).* The keys can vary widely in length, width and thickness, depending on the type of instrument. The keys of an instrument beginning at the highest pitch increase gradually in length and width, while the thickness *decreases.* (In general for a new Gender the measurements of the keys are as follows: length from 19 to 27 cm, width from 5 to 9 cm, thickness from 6 to 1 mm)[2]). See Figure 1.

Beneath every key there is a resonation tube which is stopped on the bottom and which is tuned slightly lower than the corresponding key.[3]) Nowadays the tubes are made from zinc and are all approximately 35 cm in length. The diameter and the effective length (which is determined by a zinc disk soldered on the inside of the tube, the Javanese term of which is: "tumbengan") vary with each key and determine the tuning of the tubes.[4]) Older resonators are made from bamboo which are sawed off in such a way that the joint (the so-called nodium) occurs at exactly the proper height.

[1]) The Gender was developed in approximately the 11th century (Supanggah, 1985).

[2]) There exist keys made from brass and iron (a less expensive version) while even aluminum has been experimented with. The keys are not entirely right-angled.

[3]) The difference in frequency is, according to Mr. Supanggah (1985), approximately 6 to 10 Hz. He has determined the tuning of the new Gamelan of the A.S.K.I.-academy.

[4]) With the lower keys (2nd and 3rd octave) one would expect tubes longer than 35 cm. This is the case with very old Genders. In younger instruments the opening at the top has been partially covered in order to produce a lower resonance frequency.

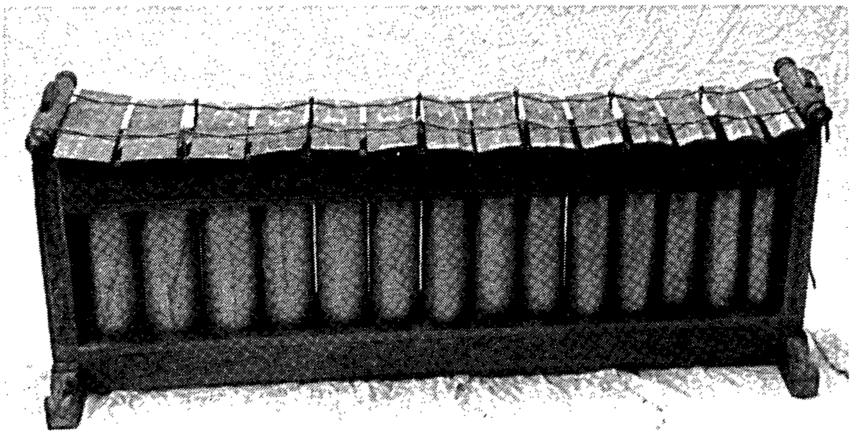


Figure 1. A Central-javanese Gender Barung.

The keys are tuned by filing them either in the middle (to lower the pitch) or on the ends (in order to raise the pitch).

The Gender is played by means of two mallets (in Javanese: "tabuh") with disk-shaped wooden heads wrapped around by cords, which gives the Gender its typically clear sound. See Figure 2. (This contrasts with the hard mallets used by Balinese Gender performers).

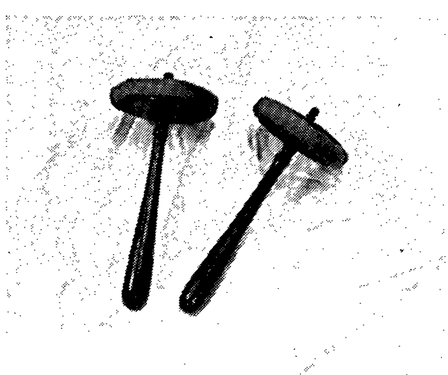


Figure 2. Gender mallets.

The Gender is produced in small factories where each craftsman gives to each instrument he makes a part of his own personality (tuning, timbre, decoration etc.).

2 EXTENSIONALIZATION OF THE PITCH IN FREQUENCIES

The extensionalization of pitch in terms of frequency forms in practice the first step towards formulizing the concept of a Gender-sound in the MIDIM-language (partI, note 14). This was obvious because the set pitches of a metallophone are a property of the instrument and not of the performer. (This is in contrast to string instruments for example). Our starting point was the Javanese concept of tuning according to the following two tuning systems.

1. LARAS SLENDRO – a five pitched scale with (theoretically) equal intervals;
2. LARAS PELOG – a seven pitched scale with unequal intervals.

Here below are given the scales in the number-notation system used in Java plus the Javanese pitch names (which are the corresponding numerals in the Javanese language):

LARAS SLENDRO	1	2	3	5	6	1		
Jav. pitch name	siji	loro	telu	lima	enem	siji		
abb.	ji	ro	lu	ma	nem	ji		
LARAS PELOG	1	2	3	4	5	6	7	1
Jav. pitch name	siji	loro	telu	papat	lima	enem	pitu	siji
abb.	ji	ro	lu	pat	ma	nem	pi	ji

In practice large differences in the tunings can occur. There is actually no standard pitch, so it is not possible to use an instrument in any Gamelan whatever. Therefore the tuning used at the radio (R.R.I.-Surakarta) is accepted more and more as reference.[5])

In order to extensionalize the above mentioned pitches it is necessary *to measure the pitch frequencies.* With this purpose in mind Jos Janssen made comparisons between recordings of various Genders and sine tones, produced by a sine-generator with a digital frequency display. The frequency was regulated until the beats became minimal. This data was compared with and supplemented by measurements performed by Suryodiningrat et al. (1972).

Via the MIDIM-function ϕ_3 (Kaegi, 1986, p. 94/5) the pitch and octave numbers for each frequency value were calculated according to a subdivision n=1200. In order that the pitches to be inputted would come as close as possible to Javanese notation, *compilers* were built into the descriptor program. (Goodman, 1986 and Kaegi, Desc user manual, 1984). The compilers assign automatically to the Javanese pitch numbers, (which are inputted via a subdivision of n=7 or n=6) the corresponding pitch numbers within a subdivision of n=1200.

[5]) A few years ago a new Gamelan was set up at the R.R.I.-Surakarta in which this reference was changed into the so-called new R.R.I.-tuning. The new Gamelan appeared not to satisfy all the expectations which one had for it, so the old tuning was once more implemented.

2.1 The slendro compiler

The Slendro system divides the octave into six segments whereby the fourth note is not used. (This representation is in accordance with Javanese pitch notation). The compilation is only applied if the subdivision is n=6. If a fourth note is made use of, then the compiler steps over to the Pelog system. (This is actually a modulation, which is very normal in Javanese music). See Table 1.

Table 1. Pitch measurements of two Slendro gamelans and their MIDIM-representations.

The following data are given: Javanese notation, MIDIM-input representation n = 6, MIDIM-output representation n = 1200 (after translation), the octave and frequencies in Hz (measurement accuracy ± 0.5 Hz).

Slendro R.R.I. (radio-Surakarta)[7]

Jav. not. [6]	MIDIM input pitch	MIDIM output pitch	oct.	Freq(Hz)
$\underset{.}{6}$	0	991	3	231.8
1	1	35	4	266.9
2	2	276	4	306.8
3	3	498	4	348.8
5	5	765	4	406.9
6	6	995	4	464.8
$\dot{1}$	1+6	48	5	537.9
$\dot{2}$	2+6	307	5	624.7
$\dot{3}$	3+6	540	5	714.7
$\dot{5}$	5+6	771	5	816.8
$\dot{6}$	6+6	1036	5	951.9
$\ddot{1}$	1+12	106	6	1112.5
$\ddot{2}$	2+12	337	6	1271.3
$\ddot{3}$	3+12	566	6	1451.1
$\ddot{5}$	5+12	816	6	1676.6
$\ddot{6}$	6+12	1061	6	1931.5
$\dddot{1}$	1+18	129	7	2254.9

Gangsa Kyai Hardja Winangun (Kraton-Surakarta)

Jav. not.	MIDIM input pitch	MIDIM output pitch	oct.	Freq(Hz)
$\underset{.}{1}$	1	14	3	131.8
$\underset{.}{2}$	2	255	3	151.5
$\underset{.}{3}$	3	524	3	177.0
$\underset{.}{5}$	5	752	3	201.9
$\underset{.}{6}$	6	1014	3	234.9
1	1+6	42	4	268.0
2	2+6	289	4	309.1
3	3+6	528	4	354.9
5	5+6	769	4	407.9
6	6+6	1017	4	470.7
$\dot{1}$	1+12	70	5	544.8
$\dot{2}$	2+12	316	5	628.0
$\dot{3}$	3+12	570	5	727.2
$\dot{5}$	5+12	846	5	852.9
$\dot{6}$	6+12	1091	5	982.6
$\ddot{1}$	1+18	145	6	1137.9
$\ddot{2}$	2+18	367	6	1293.6
$\ddot{3}$	3+18	623	6	1499.7
$\ddot{5}$	5+18	863	6	1722.7
$\ddot{6}$	6+18	1108	6	1984.6
$\dddot{1}$	1+24	128	7	2253.6

[6]) Raising and lowering a pitch by one or more octaves is designated within Javanese notation by one or more points above or below the given pitch number.

[7]) The names of the various Gamelans imply already for insiders whether the pitch scale Pelog or Slendro is concerned.

2.2 The Pelog Compiler

The Pelog system divides the octave into seven segments, so that the compilation is only applied to a descriptor track with a subdivision n=7. If this is the case, then the subdivision is automatically rewritten into n=1200 and the compilation is applied. Table 2 shows two Pelog tunings which can easily be extended.

Table 2. Pitch measurements of two Pelog gamelans and their MIDIM-representation.

The following data are given: Javanese notation, MIDIM-input representation n = 7, MIDIM-output representation n = 1200 (after translation), the octave and frequencies in Hz (measurement accuracy ± 0.5 Hz).

Pelog R.R.I. (radio-Surakarta)

Jav. not. [6]	MIDIM input pitch	MIDIM output pitch	oct.	Freq(Hz)
7̣	0	1065	3	241.9
1	1	201	4	293.8
2	2	282	4	307.9
3	3	443	4	337.9
4	4	765	4	406.9
5	5	876	4	433.9
6	6	1003	4	466.9
7	7	1138	4	504.8
1̇	1+7	228	5	596.9
2̇	2+7	354	5	641.9
3̇	3+7	508	5	701.6
4̇	4+7	777	5	819.6
5̇	5+7	919	5	889.7
6̇	6+7	1032	5	949.7
7̇	7+7	23	6	1060.4
1̈	1+14	232	6	1196.5
2̈	2+14	364	6	1291.3
3̈	3+14	506	6	1401.7
4̈	4+14	816	6	1676.6
5̈	5+14	948	6	1809.4

Gangsa Kyai Mangun Hardja (Kraton-Surakarta)

Jav. not.	MIDIM input pitch	MIDIM output pitch	oct.	Freq(Hz)
7̤	0	976	2	114.9
1̣	1	81	3	137.0
2̣	2	188	3	145.8
3̣	3	304	3	155.9
4̣	4	668	3	192.4
5̣	5	752	3	201.9
6̣	6	858	3	214.7
7̣	7	1021	3	235.9
1	1+7	54	4	269.9
2	2+7	201	4	293.8
3	3+7	348	4	319.8
4	5+7	668	4	384.8
5	3+7	765	4	406.9
6	5+7	872	4	432.9
7	6+7	1039	4	476.7
1̇	1+14	83	5	548.9
2̇	2+14	236	5	599.6
3̇	3+14	388	5	654.7
4̇	4+14	688	5	778.5
5̇	5+14	807	5	833.9
6̇	6+14	925	5	892.8
7̇	7+14	1082	5	977.5
1̈	1+21	164	6	1150.4
2̈	2+21	285	6	1233.7
3̈	3+21	442	6	1350.8
4̈	4+21	713	6	1579.8
5̈	5+21	868	6	1727.7
6̈	6+21	976	6	1838.9
7̈	7+21	1118	6	1996.1

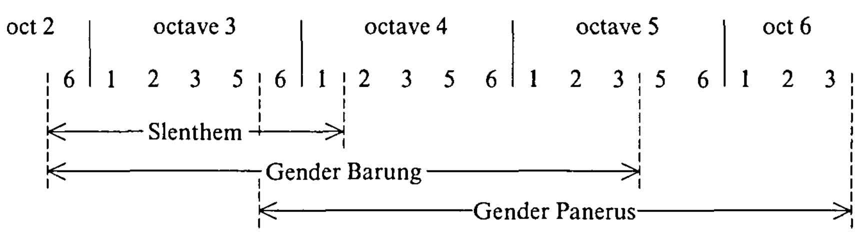
When using a predicator library (Kaegi; 1986, p. 133) every tone is directly assigned the proper predicator at the time of compilation. (In this way it was possible to build up standard Gender libraries. This marries well with the original instance duplications. See also par. 5)

3 VARIOUS GENDER FAMILIES: AN INITIAL DESCRIPTION

Now that the reader has a general impression of the Gender and the common tuning systems, we shall in what follows give a short description of a number of *Gender families.*

The most important three Genders are:
1. Gender Panerus
2. Gender Barung
3. Gender Panembung (usually called Slenthem)

Their pitch ranges are (for simplicity we limit ourselves to the tuning system Slendro; reference: chamber tone a'=440 Hz which is located in the 4th octave.):



The keys, resonators and mallets vary in size according to instrument. The Gender Panerus is the smallest, followed by the Gender Barung and then the Slenthem, which is the largest. The thickness of the keys varies in the *opposite* direction. This holds even in the case of common notes occurring between the different Gender families (see for example pitch 6, octave 3, Fig. 9). The timbral properties also vary amongst the three Gender families. We shall come back to this in detail in par. 5.4

4 THE INSTANCES i_K AND THE GENDER CONCEPT G

A physical analysis demands, as was stated in part I, on the one hand registrations of numerous instances i_K, which belong to a descriptive sound concept K, and on the other hand knowledge of the music culture MC and the context.

In 1980, 1981 and 1985 Jos Janssen undertook study trips to Central-Java in order to become acquainted with both the theory and practise of Gender performance. Via lessons and various interviews with prominent Gamelan musicians (among which Mr. Martopangrawit)[8]) he has attempted to gain an insight into the existing concepts of the Gender.

In the Kraton (the court of Surakarta) Janssen made recordings of Genders taken from four different Gamelans in 1980. These recordings are unique for various reasons, namely, the antique instruments situated there are agreed to be among the best in quality, and it was only possible to move them to one of the Pendåpå's (an open hall) where they sound to perfection, thanks to the permission of Prince Praboewidjojo. (In 1984 a large portion of the Kraton was destroyed, including the Pendåpå where the recordings took place). Further recordings took place in the museum at Bronbeek in Arnhem, the Netherlands, where six Genders (all originating from the Kraton) are in the collection.

All notes were recorded on the one hand isolated (the whole pitch range of the various instruments from near by), and on the other hand applied in a musical context (in modal improvisations, the so-called Pathetan).

An important condition for a duplication is (as we showed) a sensible definition of the concept K, so that K has a clear interpretation in the music culture MC. *Our main concept* G *is: 'The Gender sound of Genders taken from the three Gender families of the Central-Javanese Gamelan'.* It is necessary that the instrument is of a high quality (for a Javanese musician this is a clear concept, see 5.5). Naturally the instrument must be played by a reputed Gender performer. *The recordings mentioned satisfy in every way these conditions.*

Supplementary information concerning the instruments registrated can be found in Appendix II. In the following the appendix shall be referred to by means of a simple code (PAN, BAR, etc.)

5 SYSTEMATIC DESCRIPTION OF THE CONCEPT G

Now that the reader has been introduced to the duplication methods which we will follow and to a basic knowledge of the Javanese instrument Gender, we shall return to our purpose: To find a MIDIM-duplication for the Gender sound according to concept G.

[8]) Mr. Martopangrawit is one of the most important Javanese musicians. He has published a large number of books over music theory and his contributions to the Central-Javanese Karawitan are of extreme importance. (see also App. I).

A start was made in this direction with the extensionalization of pitch (par. 2). Below we proceed further by investigating the time-segmentation, the amplitude envelope and the spectra of the recorded signal.

For clarity we show each time a comparison between a registered instance and the corresponding instance derived from a MIDIM-duplication. This is in accordance with the path originally followed: in the beginning there is sought an exact MIDIM-duplication for each separate Gender note. In a later stage MIDIM-concepts are derived from out these descriptions.

5.1 Time segmentation and amplitude envelope

A time segmentation of a signal registration is the first step in the direction of a systematic analysis of a particular sound. In Figure 3 is shown the start of the signal functions and the amplitude envelopes of the 1st pitch of the 5th octave. Top left and middle show the originals struck on a Gender Panerus (PAN11), top right and bottom show its MIDIM-duplications. (The amplitude scale is linear).

The attack (top left), lasting a few milliseconds, is clearly seen, which is followed by a fairly regular signal in which the fundamental frequency is dominant. In the MIDIM-description a PREFIX of 1 to 3 ms worked wonderfully. The whole amplitude envelope of the same registration (middle) furnishes us with information concerning the other segments. The attack cannot be seen here due to the insufficient time resolution. The segmentations for the BODY, SUFFIX and STOP applied in the duplication are indicated. (bottom).

The amplitude resolution on the Y-axis is chosen in accordance with the VOSIM-variables. (see Kaegi, 1986, VOSIM) To summarize we find: (The data of the prefix can not be abstracted from the figures.)

	d (ms)	A	ΔA
PREFIX	1 à 3	(45)	(0)
BODY	54	511	-136
SUFFIX	1180	375	-175
STOP	250	200	-195
total	ca. 1490		

The amplitude decay in the SUFFIX can be interpreted as a *physical damping of the key,* while the STOP describes a *damping by means of the performers hand.* The time point of the last damping determines the *note duration.* The SUFFIX has thus a variable duration, dependent of the prosodic variable DUR. Thus: v=3 in the MIDIM-concept C'(3) (See Kaegi, 86, p. 116).

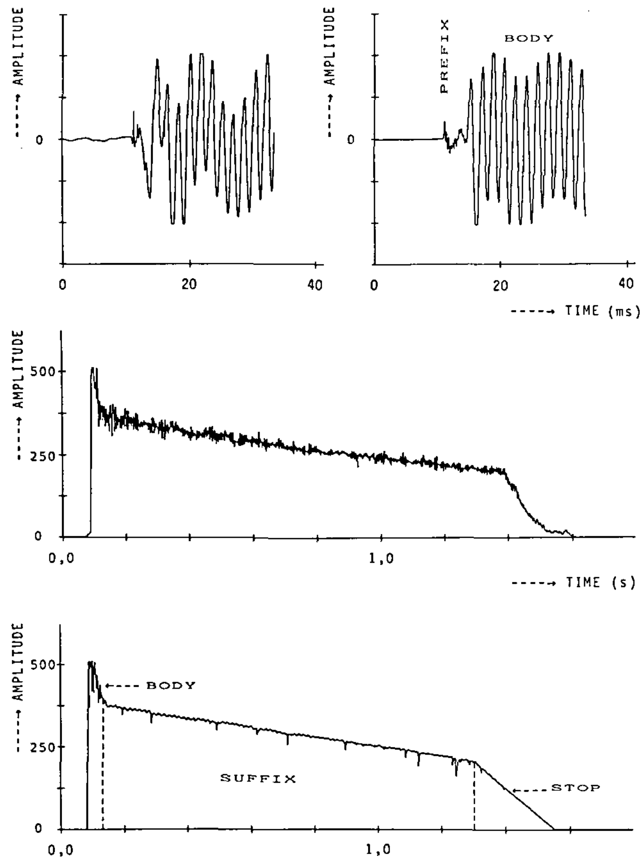


Figure 3. Signal functions and amplitude envelopes of a Gender sound, pitch 1 octave 5, $F_1 = 580$ Hz.
Compare the original signal of a struck Gender Panerus (PAN11) (top left and middle and its MIDIM-duplication (top right and bottom). The different segments are clearly seen.

5.2 A Gender Spectrum

To both the above mentioned signal registration and the corresponding MIDIM-duplication (see Figure 3), fast fourier transform is applied. (Program SIGPAC, developed by S. Tempelaars of the Institute for Sonology; for more information see Tempelaars, SIGPAC manual, 1982). Thanks to the abstraction described (see part I), the so-called peak-tracking of the data, the spectrum is clearly reproduced: see Figure 4. The frequency range runs from 125 Hz to 8 kHz and the time resolution is 16 ms.

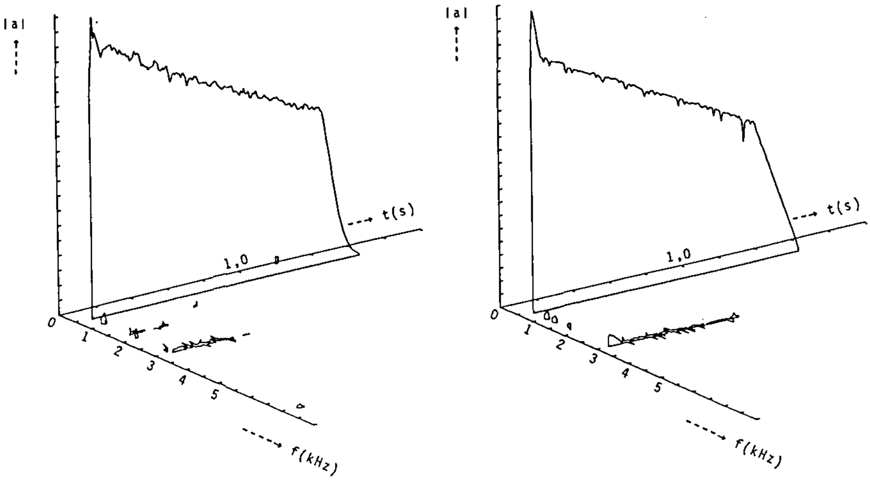


Figure 4. Spectra of a Gender sound, pitch 1 octave 5, $F_1 = 580$ Hz.

Compare the spectrum of the original signal of a struck Gender Panerus (PAN11) (left) and the spectrum of its MIDIM-duplication (right).

The most notable peak-track is found at the position of the fundamental frequency F_1, which we know from the measurements described earlier (par.2). In this case $F_1 = 580$ Hz. (Note 1 of the 5th octave in Pelog tuning (PAN11)). The amplitude as a function of time of this F_1 track agrees well with amplitude envelope of the whole signal (figure 3 middle). The second clear frequency component is found at 3 kHz although it is very weak. We shall see later that this is the 5th harmonic ($F_5 = 2.9$kHz).

Because the time resolution in Figure 4 is too insufficient the prefix is not reproduced, so as an illustration the first 20 ms (of BAR33) were analyzed and plotted; see Figure 5.
The formants and amplitudes of the plosive-like attack were determined by carefully listening to and comparing the registration and duplication.

Before we go further into the relations between spectral components and the prosodic variable pitch, we wish to draw the reader's attention to the high quality of the MIDIM-duplications. They are still *minimum* descriptions.

5.3 Dependence on the prosodic parameters
Seeking for a MIDIM-duplication demands a knowledge of the relation existing between spectral parameters and the prosodic variables T′, DUR and At. Since we are dealing only with isolated notes, and in registrations the volume can be

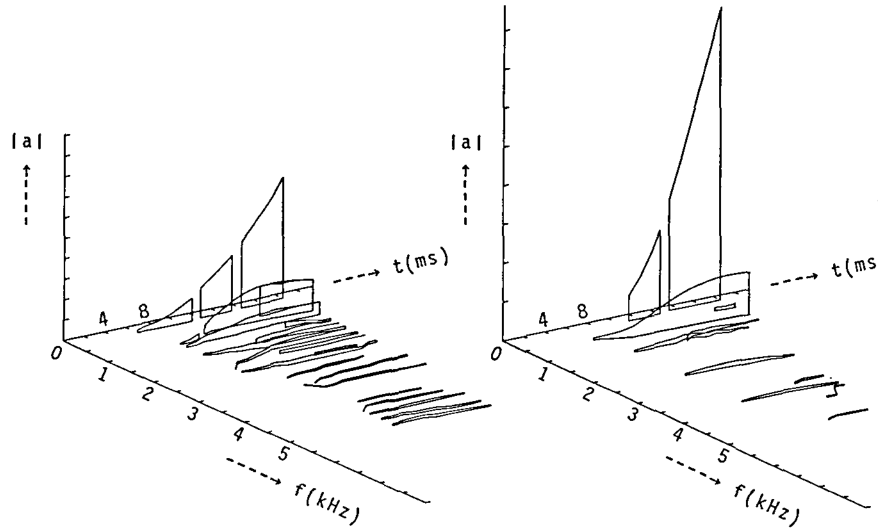


Figure 5. Spectra of the attack of the original (BAR33) (left) and the PREFIX of its MIDIM-duplication (right).

varied arbitrarily, the loudness At can be considered as a rather constant quantity. The note duration DUR, which is determined by the damping of the key by the performer, has (provided it is not too short) an influence only upon the breaking off of the amplitude envelope. The frequency of the spectral components is pretty much constant in time.

The pitch $T' = 1/F_1$ influences, on the contrary, the position of the peak-tracks in the spectra. It is sufficient to construct the spectral space R_s described earlier from the spectral parameters f,a and Δa and the prosodic parameter T'. Figure 6 shows a 2-dimensional subspace of R_s. One can see here the f-dependence of F_1 for the whole range of the Gender Barung (Mangun Hardja, Pelog).

As stated in part I, the points in this subspace stand for instances. Our purpose is to connect these with a proper MIDIM-function, which is transformed into the spectral representation. In our case the *function* F_1 is sufficient (see Kaegi, 86, p. 109). As is known T (VOSIM-formant) determines the (second) maximum in the envelope of the VOSIM-spectrum (Kaegi, 86, VOSIM, p. 74). We assume that a harmonic F_n is found at this position, then it holds that (with Of=0).

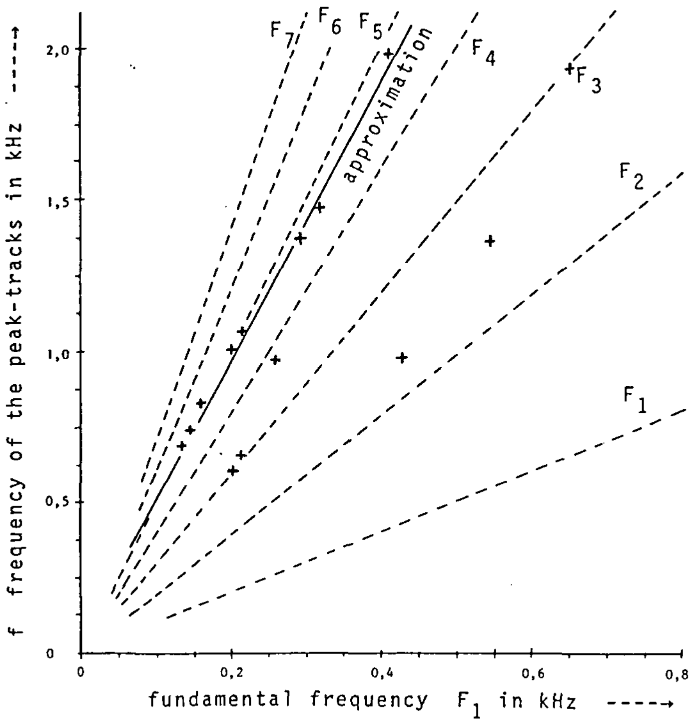


Figure 6.Subspace of R_s. Plotted are the co-ordinates (F_1,f) corresponding to the instances of a Gender (+) (Gender Mangun Hardja) and the approximation of these in the neighbourhood of the fifth harmonic F_5. The theoretical harmonics are indicated by dotted lines.

$$\left.\begin{array}{ll} F_n = n \,.\, F_1 = 1/T & \text{(requirement)} \\ q = N \,.\, T/T' & \text{(function } F_1\text{)} \end{array}\right\} F_n = N/(q \,.\, T') = N \,.\, F_n/q \qquad [1]$$

The supplementary condition that all harmonics except F_1 and F_2 must be suppressed, sets q at about 1 (assuming that c = 100%).
Formula [1] then becomes

$$F_n = N \,.\, F_1 \qquad [2]$$

N then appears to correspond with the number n of the dominant harmonic, which we have demanded. In Figure 6 are drawn the theoretical lines for the harmonics F_1 until F_7. The points in the neighbourhood of F_5 are fitted by a straight line (chi-square-criterium) of which the gradient amounts to 4.6.

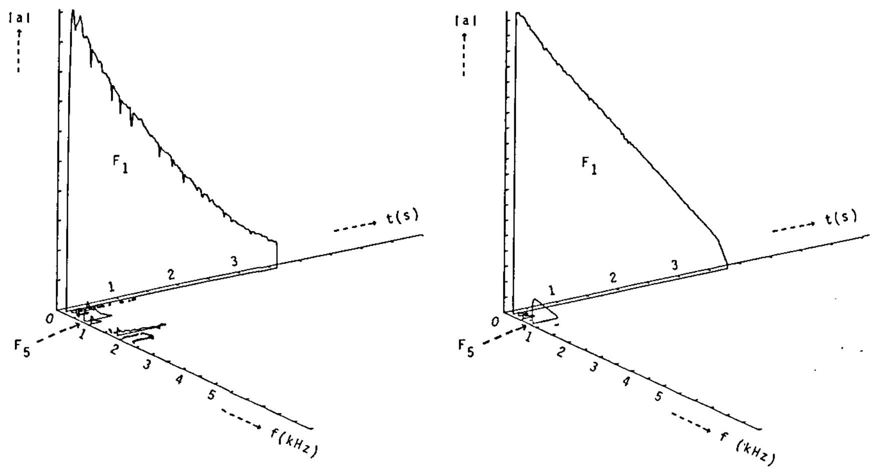


Figure 7. Spectra of a Gender sound, pitch 3 octave 3, $F_1 = 156$ Hz.
The fifth harmonic F_5 is indicated.

Compare the spectrum of the original signal of a struck Gender Barung (BAR33) (left) and the spectrum of its MIDIM-duplication (right).

We round this off to 5 and use in the described formula [2] with N=5:

$$F_5 = 5 \,.\, F_1 \qquad [3]$$

We shall speak of *the 5th harmonic in the Gender spectrum.* This is an example of how the adaptation of instances by means of MIDIM-functions can be realized within the space R_s.

Naturally there are more changes in the spectrum as a function of pitch than has been shown above. For example the amplitude of the F_5-track is pitch dependent, as is shown in Figure 7 (spectra of pitch 3, octave 3 (BAR33)).

Comparing this Figure with Figure 4 (pitch 1, octave 5) shows that the harmonic F_5 in the low pitch range is more dominant at the beginning but rapidly decreases. Two octaves higher (pitch 3, octave 5) F_5 is weak although it is played on the same instrument. On the other hand, we find a strong component with a frequency lower than that of the fundamental. See Figure 8. Also the timbre as well as the intensity of the attack vary with the pitch.

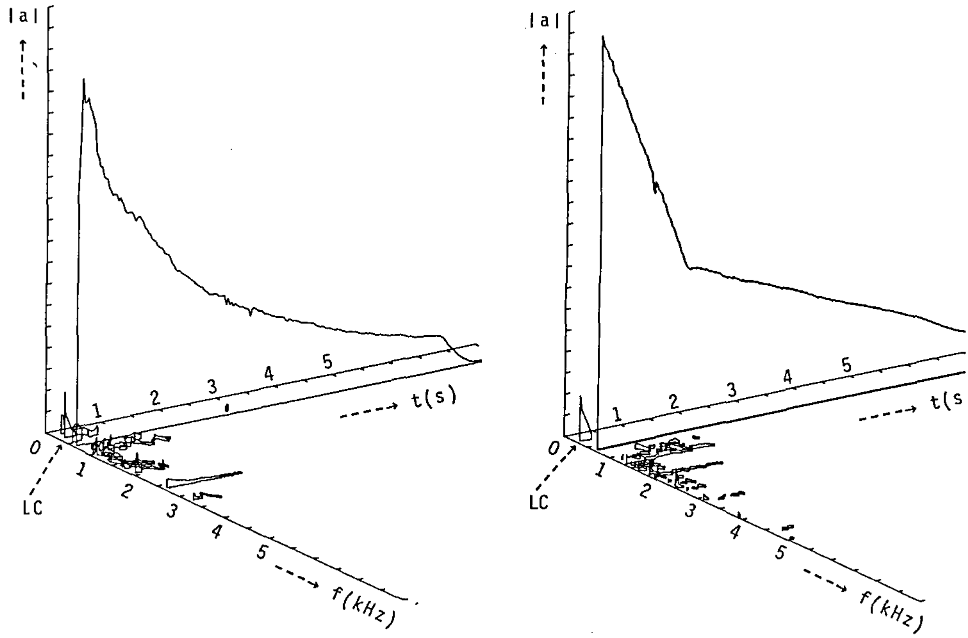


Figure 8. Spectra of a Gender sound, pitch 3 octave 5, $F_1 = 655$ Hz.
The low component (LC) can be clearly seen.

Compare the spectrum of the original signal of a struck Gender Barung (BAR03) (left) and the spectrum of its MIDIM-duplication (right).

5.4 The three Gender families

In paragraph 3 we gave the first description of the three current Central-javanese Gender families, which together embrace practically the entire pitch range. The physical difference in the signals of the three Genders takes place in the amplitude envelope. This clearly audible difference is illustrated in Figure 9, which reproduces pitch 6 in the 3rd octave struck on resp. the Gender Panerus, the Gender Barung and the Slenthem. While the keys of the Panerus damp *logarithmically*, those of the Gender Barung approximate a *linear* decay. The amplitude envelope of the Slenthem is in the first 3/4 seconds nearly constant after which a slight logarithmic decay takes place. A correct tuning of the keys and resonator is here of great influence. In this way the amplitude envelope differs considerably per key.

The spectra as well are not entirely identical in the various instruments. Although some show correspondences in the three families,the corresponding keys are not equally large. The large keys bring about the fifth harmonic while the small keys on the other hand produce the low component, analogous to the difference between low and high notes. Also by means of these characteristics the three Gender families are thus characterized.

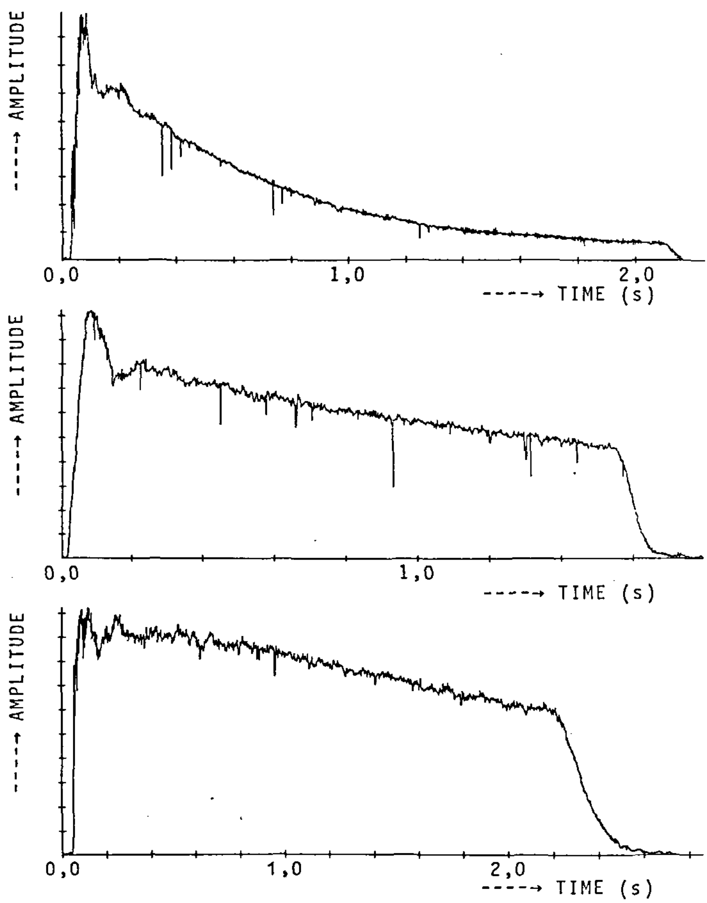


Figure 9. Amplitude envelopes of instruments of the three different Gender families.

At the top the Gender Panerus (PANCO), in the middle the Gender Barung (BARCO) and at the bottom the Slenthem (SLECO).

5.5 Quality differences

The Genders which we have spoken of up to this point are of particularly good quality. They approximate the sound ideal of Javanese musicians for what concerns a Gender:[9])

1) The fundamental must be the strongest component in the spectrum. By this the clear strident sound is created.
2) The instrument must sound the same from a distance as well as up close (This depends strongly upon point 1).

Generally old instruments satisfy these points very well, because they have been brought into balance in contrast with the new Genders. We can see the difference very well in the spectra (Figure 10). Represented are time (on the horizontal axis) and frequency and amplitude (both on the vertical axis; the reduced scale at the beginning of the axis indicates the amplitude, peak-tracks are drawn as closed figures. See van Berkel, 86, p. 239).

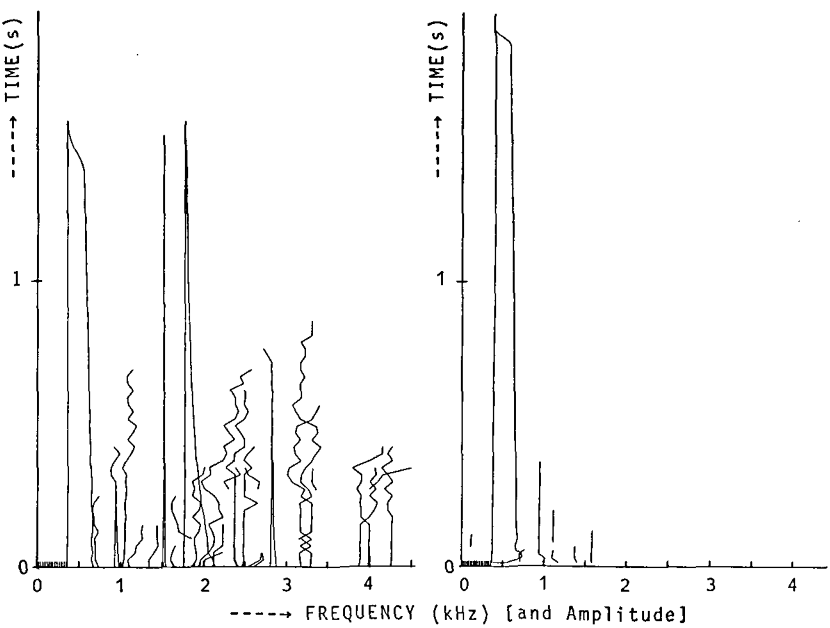


Figure 10.Spectra of a 3 year old Gender (BARNEW) (left) and a ca. 80 year old Gender (BAROLD) (right). (pitch 3 octave 4).

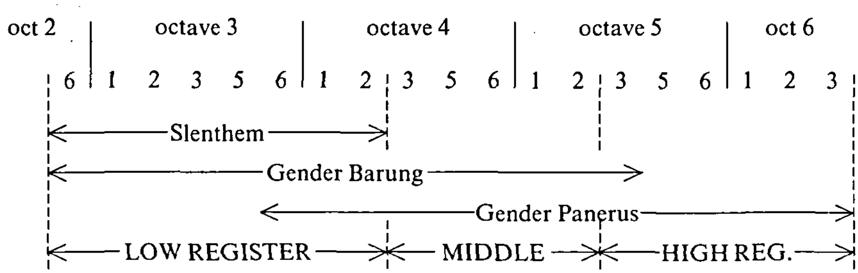
[9]) This sound ideal was notated by Janssen in interviews with S.D. Humardani (†83, previous-director of the A.S.K.I.-academy of Surakarta) and Mr. Martopangrawit (head-master at the A.S.K.I.-academy).

6. A GENERAL MIDIM-DESCRIPTION OF THE CONCEPT G

When proceeding from the MIDIM-duplication we discussed in detail the physical properties of the Gender sound (in light of the VOSIM-spectrum). How one shall realize these within the MIDIM-language has not been dealt with as yet.

6.1 Segmentation of the pitch range into registers

In the frame of the MIDIM8X-system it appeared not to be possible to describe the general concept G for the Gender sound with one single predicator which could be applied over the whole pitch range (par.3). A division into the registers "high", "middle" and "low" was necessary for this purpose. The sound of each register is described by a specific predicator[10]).



In frequencies in Hz:
Low reg.: $F_l = [117,309]$, mid.reg.: $F_l = [309,628]$, high reg.: $F_l = [628,1500]$.

The MIDIM-vectors needed will be shown per segment for the three registers.

6.2 The MIDIM-description applicable in the middle register

Here we shall discuss the MIDIM-vectors used, the concepts C'(v) and the most optimal values, applicable for the *middle* register.

We refer generally to the theory introduced by W. Kaegi in his articles concerning the MIDIM-language and the VOSIM-system (this issue).

[10]) The existing register segmentation could be avoided by expanding the function tables so that the amplitude contour of specific spectral components can be made dependent upon T'.

6.2.1 The following MIDIM-vectors are used:

$\vec{m}_l = (\lambda F_{12}).\vec{m}_0 = \lambda T', \Delta T', Sp, Of.(T, \Delta T, M, \Delta M, A, \Delta A, C, N, D, S, MF, F_{12})$

$\vec{mg}'_0 = (\vec{m}_l\ )(c_S, c_{MF}, c_D, c_C\ , c_{\Delta A}, c_{\Delta M}, c_{\Delta T}) =$
$= (\vec{m}_l\ )(0\ , /\ \ , 15, 100, 0\ \ , 0\ \ , 0\ )$

$\vec{mg}_0 = (mg'_0)(c_d, c_N\ , c_A, c_{\Delta A}\ , c_M\ , c_T)$

Within vector $\vec{mg}_0$ none of the prosodic parameters is λ-tied so that $\vec{mg}_0$ becomes suitable for the PREFIX of our Gender predicator.

The following vector $\vec{mg}$ is derived by us from the vector $\vec{m}_{651}$, which is presented by W. Kaegi in paragraph 3.6 concerning metallophone-like sounds (p. 110):

$\vec{m}_{651} = (\lambda\ F_6\ F_5\ F_{11}\ F_9\ \phi_6\ F_2\ F_1\ F_4\ F_3\ F_{12}) \ldots, d.\vec{m}_0$

$\vec{mg}' = (\vec{m}_{651})(c_N, c_q\ , c_P, c_{Of}, c_e, c_{y2}, c_C\ \ , c_S, c_{Sp}, c_W) =$
$= (\vec{m}_{651})(c_N, \frac{3000}{3006}, 0\ , 15, 1\ , 1\ \ , 100, 0\ , 0\ \ , 0\ )$

$\vec{mg} = (\vec{mg}'\ )(c_{Am}, c_{\Delta Am})$. This vector is implicitly described in par. 5.3. It produces the *fundamental* F_l and the *harmonic* F_N. The other harmonics are suppressed.

By simplicity we add to these vectors an index, which indicates the value of c_N. Thus $\vec{mg}_1$ produces only the fundamental, because $c_N = 1$.

6.2.2 The concepts

By means of these vectors the following concepts are built up, wherein the third segment, the SUFFIX, has a variable time duration $d_3 = \phi_5\ (d_i, DUR)$. Thus $v = 3$. In the PREFIX is $c_{\Delta A} = 0$.

$Gm = (C'(3))(\vec{mg}_0, \vec{mg}_1, \vec{mg}_1, \vec{mg}_1)$ applicable in *both* tracks.

In the first track:

$Gm1 = (C'(3))$ { $(\vec{mg}'_0)(c_d, c_N, c_A, c_M, c_T)$
1 1 55 15 360, PREFIX

$(\vec{mg}'_1)(c_{Am},$	$c_{\Delta Am})$	i	
500,	—250	2	BODY
250,	—175	3	SUFFIX
75,	— 75	4 }	STOP

In the second track:

$Gm2 = (C'(v))$ $\{(\vec{mg}'_0)(c_d, c_N, c_A, c_M, c_T)$

1	1	40	150	200,	PREFIX

$(\vec{mg}'_1)(c_{Am},$	$c_{\Delta Am})$	i	
65 ,	—35	2	BODY
30 ,	—20	3	SUFFIX
10 ,	—10	4 }	STOP

The 'm' in the names 'Gm' indicates the middle register.

6.2.3 The predicator used is:

$$PGm = (\lambda L_1\ L_2\ L_{33}\ L_5)\, v, d_2, d_4, bea, DUR, T', At.(Gm1, Gm2)(7, 160, 60, 3)$$

The link function L_{33} gives us a constant *beat frequency* of (in our case) 7 Hz, and simulates thus the difference between the tuning of the key and the corresponding resonator (See par. 1, note 3).

6.2.4 The domains of the parameters used

The values shown in the above tables are applicable for an optimal case. Within the general Gender concept presented these parameters may vary over particular domains of which we shall now mention a few:

a) The most important parameter in the PREFIX is the time-duration d_1. It holds approximately: $d_1 \in [1,5]$.
The other parameters may vary extremely and should be chosen experimentally (Kaegi, 1967).

b) The amplitude contour can be varied by which means *the differences existing between the various Gender families* may be formalized.
(These values can be abstracted from fig. 9, par. 5.4)[11]).

c) As has been shown in par. 5.5 the amplitude A_{F_5} and the duration of the harmonic F_5 determine the differences between one Gender and another.

[11]) As we have seen the Gender families differ mainly in their amplitude contours. The linear amplitude changements can be described by means of the present MIDIM/VOSIM-model very well (parameters A and ΔA). The logarithmic envelope of the Gender Panerus offers more problems. In order to solve this problem one can extend the number of segments, so that a step approximation of the envelope becomes possible. Another solution lies in the hardware of the VOSIM-generators which up until now could only give a linear interpolation over a segment.

In general the following extreme values are valid:

New instruments: - $A_{F_5} \simeq A_{F_1}$ *in the beginning of the BODY, but the amplitude of* F_5 *decreases rapidly.*
- *The duration of* $F_5 \simeq$ *duration of* F_1.

Old instruments: - $A_{F_5} \simeq 0$.

See Figure 10.

6.3 The MIDIM-description applicable in the other registers

Starting from the MIDIM-description of our Gender concept G for the *middle* register, we can extend this duplication to the *low* and the *high* register *by replacing some vectors in the second track.* In the PREFIX only *some characteristic values* are changed.

6.3.1 The concepts

In par. 5.3. was shown that the spectrum of low pitches contains the fifth harmonic F_5 with a small amplitude in the first 60 ms of the signal. To simulate this we replace in the BODY and the SUFFIX of concept GM2 the vector $\vec{mg}_1$ by the vector $\vec{mg}_5$ (thus $c_N = 5$) and adapt the amplitude within this track.

For the high pitches there appeared, as was shown, a low component in the spectrum. We introduce this in our concept GM2 by replacing vector $\vec{mg}_1$ by $\vec{mg}_0$ in the BODY ($\vec{mg}_0$ is pitch-independant).

	PRE	BOD	SUF	STO	
GH2 = (C′ (3))	($\vec{mg}_0$,	$\vec{mg}_0$,	$\vec{mg}_1$,	$\vec{mg}_1$)	high register
GM2 = (C′ (3))	($\vec{mg}_0$,	$\vec{mg}_1$,	$\vec{mg}_1$,	$\vec{mg}_1$)	middle register
GL2 = (C′ (3))	($\vec{mg}_0$,	$\vec{mg}_5$,	$\vec{mg}_5$,	$\vec{mg}_1$)	low register

For comparison the middle register is also indicated.
Compare the used concepts with the figures 4, 7, 8.

6.3.2 The values used:

In the first track: (assumed is $c_{\Delta A} = 0$)

GH1 = (C′ (3)) {($\vec{mg}'_0$) (c_d, c_N, c_A, c_M, c_T), PREFIX high reg.
1 1 63 15 100

($\vec{mg}'_i$) see middle register for i = [2, 4]}

GL1 = (C′ (3)) {($\vec{mg}'_0$) (1, 1, 45, 15, 90), PREFIX low reg.

($\vec{mg}'_i$) see middle register for i = [2, 4]}

In the second track:

$GH2 = (C'(3))$	$\{(\vec{mg}'_0)$	$(c_d,$	$c_N,$	$c_A,$	$(c_{\Delta A}),$	$c_M,$	c_T	$)\ i$	high register
		1	1	45	0	15	60	1,	PREFIX
		60	1	125	−125	10	2000	2,	BODY

$$(\vec{mg}'_1)\quad (c_{Am}, c_{\Delta Am}) = (\vec{mg}'_1)\,(0,0) \text{ for } i = [\,3,4\,]\}$$

$GL2 = (C'(3))$	$\{(\vec{mg}'_0)$	$(c_d,$	$c_N,$	$c_A,$	$c_M,$	$c_T,$	$)$	low register
		2	2	36	152	56		PREFIX

$(\vec{mg}'_5)$	$(c_{Am},$	$c_{\Delta Am})$	i	
	45	40	2,	BODY
	5	5	3,	SUFFIX

$$(\vec{mg}'_1)\quad (c_{Am}, c_{\Delta Am}) = (\vec{mg}'_1)\,(0,0) \qquad \text{for } i = 4\}$$

6.3.3 The predicators PG1 (low) and PGh (high) are analogous to PGm (middle).

7. TESTING THE DUPLICATIONS

It was made clear in part I that *an experiment* was necessary in order to decide if the instances belonging to a predicator P sound like the corresponding instances, derived from the concept K, in our case G (see scheme part I, Fig. 1).
For the testing of the various Gender predicators (of which we have shown here the most general form) all three of the methods described (part I par. 6.7) were applied:

1) During his second study trip to Java in 1981, Jos Janssen played to Javanese musicians Gender duplications made with the MIDIM-system which had been recorded on tape. Further, the well known Javanese musician *Supanggah Rahayu,* while on a tour to the Netherlands (he was soloist in the composition Dialogue, see composition list: Goodman, 1986, p. 182), listened to duplications which he then could criticize. On the basis of his comments the original description in three segments was extended to four. By this means it was possible to bring into play the typical *damping of the performer* within the concept (STOP in the described segmentation)[12]. Also the compilers (discussed in par. 2) were

[12]) In the case that the STOP should be missing, then the amplitude must decrease to zero during the SUFFIX. Mr. Supanggah commented that, when this was so, a Gambang (Javanese Xylophone) was approximated rather then a Gender. After his remarks we naturally tried to make a duplication of the Gambang. A few instances were duplicated derived from the Gender predicator with roughly the following alterations: the amplitude contour (a very strong decrease in the body) the Stop is the variable segment in duration.

tested in this way. Mr. Supanggah himself recognized the tunings he had applied to the original instruments.

2) In order to compare the instances *test tapes* were set up in which an original sound of a struck key was always followed by its duplication. Many test persons could not differentiate the orignal instances from the duplicated instances. (At the dutch AES-convention, 1985, Dr. W. Kaegi showed among others some MIDIM-duplications of the Gender. The critical audience kept silent when they were asked to distinguish the original from the duplicate).

3) The instances were compared *spectrally* many times. We do not need to go any deeper into this because the reader has already met a number of comparison examples in the text.
These tests proved sufficiently that the duplications satisfied the concepts to which G belongs.

8. MUSICAL APPLICATIONS OF GENDER CONCEPTS

Apart from the general or family related concepts of the Gender, attempts were made to duplicate *individual* instruments so accurately as possible. For this reason *predicator libraries* were built up with a large number of registers. For artistic applications it appears that these descriptions are highly satisfactory because of their variety which makes them living. (La Belle et La Bête by Goodman/Janssen and Dialogue by W. Kaegi, see composition list page 182).

In order to illustrate this we will show here an example, once more presented in the spectral space. See figure 11. (The signals are filtered in such a way that only the fundamental can be seen). It is the beginning of a so-called *Modal improvisation Laras Pelog Pathet 7,* performed by Doyopangrawit in the Kraton of Surakarta upon the Gender Mangun Hardja. The melody in Javanese notation looks as follows:

7 . . . . 2̇ 6 7 right hand
. 7̣ 5̣ 6̣ 7̣ . . . left hand

A point above a number raises a note by an octave. The points under lower the note by an octave (see pag. 201, note 6). It is important to state that a performer damps the keys whenever the following note is struck so that the notes overlap one another. The overlapments can be clearly seen in the spectra. (These overlapments in the duplication are calculated by a special overlap facility, implemented in the descriptor program).(See Kaegi, 1984.)

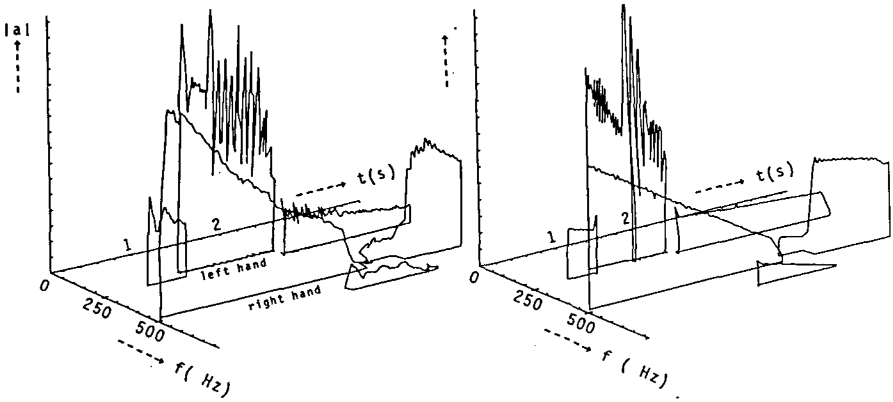


Figure 11.Spectra indicating the fundamental frequencies of the following melody:

7 . . . . 2̇ 6 7	(right hand)	(above 400 Hz)
. 7̣ 5̣ 6̣ 7̣ . . .	(left hand)	(below 400 Hz)

Compare the original played on a Gender Barung (BAROV)(left) and its MIDIM-duplication (right). Note that the pitches 6 and 7 played by the right hand are represented by one peak-track; the same holds for the pitches 5 and 6 played by the left hand.

9. FUTURE DEVELOPMENTS

It is intended that, with the help of the new MIDIM9-system and compatible pattern recognition systems, further experiments shall take place with duplications. On the one hand investigations into the non-western sound world will receive attention, through which *ethnomusicological researches* will be possible on a large scale. In connection with this one can for example think about *formal comparisons of instruments and language within the same culture.* By means of this the questions as to *what is a musical sound* shall acquire a formal foundation. On the other hand in the future there shall, by means of duplications and through sound libraries (which will be developed on the basis of these duplications), arise *intensional descriptions of the sounds* which the composer wishes to have at his disposal. The expression "I would like something which sounds like a Gender 'and' the song of a blackbird" can then be *directly* extensionalized in the MIDIM-language, after which the desired sound – if it is physically realizable – will be supplied by the system (Kaegi/Janssen/Goodman, 1986).

APPENDIX I

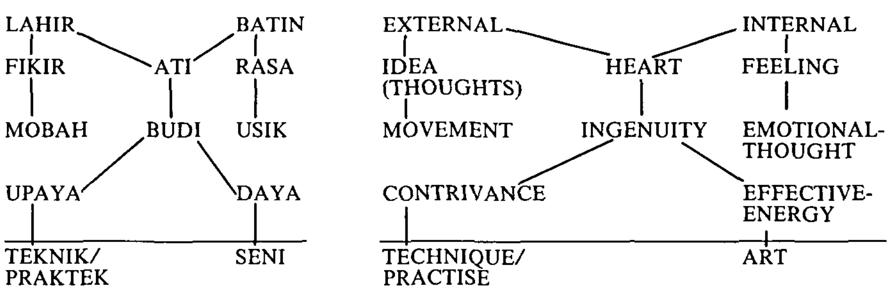
In this appendix we will deal with some supplementary basic concepts which are valid within *the Music Culture (MC) of Java:* the musical concepts 'GARAP', 'GARAP PATHET' as well as the concept 'MODULATION' and the sound concept 'GONG'.

We shall base our discussion upon the doctoral dissertation 'INTRODUCTION AUX STYLES ET INTERPRETATION DANS LA MUSIQUE JAVANAISE' written by Dr. Rahayu Supanggah (1985), as well as the book 'PENGETAHUAN KARAWITAN' written by R. L. Martopangrawit (1975). Moreover use shall be made of personal interviews conducted by Jos Janssen with Mr. Martopangrawit in Solo (1981 and 1985).

1. INTRODUCTION

In one of the interviews Mr. Martopangrawit (nov./dec '85) gave a scheme concerning the arts which according to him must hold before the term 'art' may be applied. We will now show the scheme but without going into too many details. (There appear to be certain correspondances between the following scheme and various aspects of the philosophy of Aristotle.)

'SCHEMA KEBUDAYAAN' (literally: scheme for the arts) constructed by Martopangrawit



In the scheme above there are two main processes 1. the external,
2. the internal

Within the two processes we constantly find complementary levels which must be harmonized, such as fikir-rasa (idea/feeling), mobah-usik (movement/emotional-thought), etc. Imagine that you suddenly want to go to the cinema (emotional-thought), then of course you have to get to the cinema somehow (movement) and to have sense enough to buy your ticket and stay out of jail (ingenuity). According to Mr. Martopangrawit every artist in a state of development passes through these various stages and for each stage there are intensionally and extensionally interpreted concepts. Although these concepts were in the past hardly notated and thus may seem somewhat unclear to Western musicologists, *they are quite clearly defined what concerns the local musicians and moreover are easily demonstrable on their instruments.*
(In the last few decades many publications have appeared with the purpose of setting these concepts down in writing. Most especially at the A.S.K.I.-academy, Surakarta, Indonesia.)

In what follows a number of these concepts shall be dealt with in detail.

2. GARAP

The Javanese concept *Garap*, which may be translated as *"interpretation"* when first making contact with the term, plays a central role in the Karawitan. Garap is defined by Dr. Supanggah in the following way: *"Garap is concerned with the domains of creation, interpretation, and even inspiration and imagination. (...) The Javanese artist possesses a great deal of freedom within the Garap."* One should pay attention that the notion of freedom must not be confused with the concept of improvisation.

"The Javanese shadow-play, the Wayang Kulit, could be helpful in clarifying the term Garap and the freedom the artist enjoys: for the same drama (Lakon) the effect, the style and the content may vary according to the puppeteer (Dhalang) and the circumstances, which means the moments when the play comes to life or the scenery (ambiance). Thus for a single drama every puppeteer may create a different "Garap" or "Sanggit" (Sanggit is the creativity of the Dhalang).

The Dhalang may vary the following among others:
1. *the order of the scenes*
2. *the accent laid upon the personalities of certain characters*
3. *the plot in the progress of the drama*
4. *the choice of the movements of the puppets* (Sabet)
5. *the music accompanyment*
6. *the rhythm of the performance*

etc."

"The Lakon is nothing more than a framework within which the puppeteer may build or arrange the drame entirely in accordance with his talent and imagination (...)."

Within the general concept of Garap one may mention among others the following sub-concepts:

1. GARAP LARAS (tuning system): there are two tuning systems namely Pelog and Slendro[1]). It is possible to perform very many melodies in both systems but it obliges one to reinterpret the individual parts/melodies. The tuning systems are based upon the Javanese concept *Embat Alam* (natural interval). When tuning the instruments this fact is taken into account. During a performance, the musicians give their own interpretation to the tuning system particularly the *Pesindhen* (female singer), the *Rebab* (two-stringed fiddle) and the *Siter*. One could speak of *dynamic tuning systems*[2]).

2. GARAP IRAMA (rhythm, tempo): every rhythm necessitates another interpretation (Garap). Rhythm in the sense of "(...) *the expanding and contracting of structural units such as the* Gastra *(musical unit of four basic melody-notes) and the degree or level at which the Gatra is subdivided (or filled in)."* (Becker, 1984).

[1]) In antique Javanese poetry there is sometimes references to 3 tuning systems, namely Slendro, Pelog (Pelog 6) and Barang. (Information derived from B. Arps, Javanist in Leiden, the Netherlands.)

[2]) Mr. Martopangrawit related in one of the interviews that once he was asked to play a siter. At the beginning of the concert he tuned the instrument to the Gender. During the first composition it appeared that the tuning did not harmonize with the rest of the orchestra (Gamelan) thus for the next composition he tuned the instrument to the Slenthem. Afterwards it still seemed to be the case that the tuning was not right and he decided to tune to the sound of the entire orchestra which produced the desired results.

3. GARAP PATHET (mode, tonality): there are three modes per tuning system, which obliges a particular musical interpretation (as far as ones knowledge extends). See also under the header *Garap pathet.*

4. GARAP of the DYNAMICS: a less developed concept within the total Garap. Only in the last ten years has there been much work done to develop this concept by means of new compositions with strong contrasts in the dynamic level.

5. GARAP of the ORCHESTRATION: traditionally the orchestration within a composition is fixed. A term which would be equivalent to *'solo-instrument'* does not exist. Even the singers follow the same rules as those pertaining for the instrumentalists and only through recording techniques are the male or female singers allowed to dominate the rest of the orchestra. Since 10 or 15 years experiments have been conducted in the field of orchestration such as using a drum set for a dance performance or using various instruments from different parts of Indonesia, but before this time it was not common practise.

One of the dangers arising from an admixture of various instruments and styles is according to Mr. Martopangrawit (interview, nov. 1985)
"that music and dance etc. is becoming less and less abstract; tending to refer too much to daily events such as the grinding of rice or the influence of radio and television (...)". One of the most important foundations of Javanese culture is just this abstraction in form within music, dance, the Wayang kulit, the Batik, etc.

3. GARAP PATHET

Pathet can according to Dr. Supanggah be defined in the following way: *"It is a Javanese musical system which classifies the compositional repertoire according to its range (or register), the proper moments when they may be played by someone (the artist), or the order in which someone may play them, the feeling the composition evokes, the vocabulary of the execution and the tonal hierarchy".* (Supanggah, 1985).

There exist disagreements concerning the concept Pathet but we will not go any further into this at the moment. A thesis on this subject is being written by Mr. Sri Hastanto at Durham University, England. Mr. Supanggah points out that the interpretation of Pathet (Garap Pathet) is also dependent upon the artistic meaning each player gives to it and depends on the choice of the melodic patterns (*Cengkok*), their variations (*Wiled*) with respect to the other instrumental and vocal parts. A Javanese musician is able to show his talent and richdom qua *Garap* by means of different Wiled, which differ with each performance.

A composition in Javanese music only achieves its final realization with its interpretation (Garap) during a performance. For this reason the musicians dislike to have their parts written out as they feel it limits their personal interpretation, although a concise guide for a performance is given by means of a basic notated melody (called in Javanese *Balungan*).

To leave scope for Musical freedom Javanese music is severely structured, which Mr. Martopangrawit termed during one of the interviews *"freedom within knowledge"* which every artist must attain (...) *within the Karawitan one is very free but not so free as to take a train without buying a ticket (...), only someone who understands the concept of Garap is able to explain the composition* (Gending), *the mode* (Pathet) *and the tuning system* (Laras)".

Within each tuning system the following Pathet terms and corresponding pitch scales are stated:

LARAS SLENDRO PATHET	SANGA	(=9)	5 6 1 2 3
	NEM	(=6)	2 3 5 6 1
	MANYURA	(=?)	6 1 2 3 5
LARAS PELOG PATHET	LIMA	(=5)	5 6 1 2 3
	NEM	(=6)	2 3 5 6 1
	BARANG	(=7)	6 7 2 3 5

The modal term *Manyura* means "peacock" in Sanskrit while the other terms designate a number in Javanese. (In India the pitches were designated by names for animals, continents and heavenly bodies etc. (te Neyenhuis, 1970). Concerning the pitch scales of *Laras Pelog* there are many differences in opinion as to which notes are the tonic, dominant, sub-dominant etc. It is possible that the dissertation mentioned above of Sri Hastanto in Durham will clear up this matter. (The scales mentioned above were taken over from Martopangrawit (1975) discussing the item.)

The *Gender* (*Gender Barung*) is the most important instrument for the accompanyment of the puppeteer (*Dhalang*). The Gender player must keep the puppeteer in the correct Pathet for the whole 9 hour duration of the performance (three Pathets each lasting 3 hours). Each Pathet expresses a particular state of mind and a good performance demands of the musician an extensive knowledge of the basic concepts Garap and Pathet mentioned above.

The wife of a puppeteer often plays the Gender during a Wayang performance, thus there exists a *female style of Gender performance:* certain special variations (Wiled) are only used by female Gender players. However it is nowadays difficult to point out exactly what the difference is between the Gender-performance of male or female.

Among Javanese musicians there exists a special term for the quality of an instrumental sound: *Nyopak* (*"This Gender is Nyopak"* (is good)). The tuning of a Gender does not seem to be terribly difficult at first sight (when one tunes the tubes and keys in accordance with each other, then the Gender seems to be Nyopak), but it is possible to tune a Gender in such a way that a particular Pathet becomes more "precisely" tuned than the other two Pathet. This demands knowledge of the concepts Garap, Pathet and naturally Laras. Nowadays the Pathet Manyura is often used for the "precise" tuning in Laras Slendro, while not so long ago Pathet Sanga was also used. For modulations the tuning is of importance as well.

4. MODULATION

There are two modulations
1. modulation of Pathet
2. modulation of tuning system

In order to make it possible to modulate from one tuning system to another it is necessary that one of the notes must be common (*the Tumbuk-note*). A melodic phrase or sentence is always closed by striking a *Gong*; with a modulation the Gong-note is identical to the

Tumbuk-note. Usually this is note 5 (Tumbuk 5) or 6 (Tumbuk 6): note 5 for *Laras Slendro Pathet Sanga* and *Laras Pelog Pathet Bem* (Pathet 5 and 6) and note 6 for *Laras Slendro Pathet Manyura and Laras Pelog Pathet Barang* (and the seldom used fourth pathet Pelog Manyura with the scale 6 1 2 3 5). When constructing the compilers we took into consideration the Tumbuk-note. (The gamelans from out the Kraton Mangun Hardja (Pelog) and Hardja Winangun (Slendro) use Tumbuk 5, the R.R.I. tuning Tumbuk 6, see page 201/202).

In the following scheme which has been taken over in part from Mr. Martopangrawit (1975) the theoretical intervals within the systems Slendro and Pelog are shown.

Slendro:	pitch	1	2	3	5	6	1		
	cent	240	240	240	240	240			
Pelog:	pitch	1	2	3	4	5	6	7	1
	cent	150	150	225	150	150	150	225	

The Pelog scale could possibly give an explanation why exactly the three Pathet which we have named are used: the theoretical intervals in the three Pathet made use of are identical, namely:
150,375,150,375,150 cent. This might be why these are used so often while Pelog Pathet Manyura (375, 150, 150, 375, 150 cent) is seldom applied.

The fact that there is *no standard pitch* may also play a role in the Garap of a composition: certain compositions sound better when played upon certain Gamelans. In the court of Surakarta (Kraton) one will find various different Gamelans in residence. One of the Gamelans of the A.S.K.I.-academy which was tuned by Dr. Supanggah (who apart from his work as head-teacher at the academy performs sometimes as a puppeteer) is particularly suitable for the *Wayang Kulit.*

5. THE SOUND CONCEPT "GONG"

One finds in the Music Culture of Java *duplications of instrumental sounds made with the help of other instruments. Gong sounds* for example can be made by the following differing instruments:

1. The GONG AGENG (large gong): consists in its usual form from out a round bronze plate with a large bulge in the middle, where he is struck with the fist or a cudgel.

2. The GONG KEMODHONG: is composed from out two bronze keys with earthenware resonators mounted in a wooden cabinet. The keys and resonators are tuned slightly apart (ca. 6 Hz). The Gong Kemodhong gives an extremely good duplication of the sound concept Gong (this instrument is very suitable for small ensembles, the so-called *Gamelan Gadhon*).

3. The GONG BUMBUNG: is composed from out a thin bamboo tube and a thick stopped resonator. The resonator is brought into vibration by blowing into the thin tube. A good performer is capable of producing a surprising duplication of a large Gong; only through the decay does it become clear that it is a blown instrument (sudden breath pause).

4. The Human Voice: The word Gong is onomatopoeic. By calling out the word one duplicates the concept via speech and in this way it is even possible to imitate complete Gamelans.

NOTE: If mistakes and incorrect interpretations concerning Javanese theory are found in this article the fault lies with the authors.

APPENDIX II

Information concerning the Genders made use of:

BAR33,BAR03 en BAROV
Gender Barung Laras Pelog taken from out the Gamelan KYAI MANGUN HARDJA which is situated at the KRATON SURAKARTA, Indonesia: figures 5-8 and 11

PAN11,BAROLD,PANCO,BARCO en SLECO
Gender Panerus, Gender Barung, Slenthem Laras Slendro and Pelog taken from out the Gamelan KYAI NUGROHO PURADININGRAT MAESO which makes a part of the collection of the Bronbeek museum in Arnhem, Holland. This Gamelan comes originally from the KRATON of SURAKARTA: figures 3,4,9 en 10

BARNEW
Gender Barung Laras Slendro, RRI-tuning, manufacture date 1982: figure 10

APPENDIX III

Information concerning the spectral analyses:

The spectral analyses are performed by means of the signal processing programs SIGPAC, developed by S. Tempelaars.

figure	code	sampling rate	window widt/shift	type
3,4	PAN11	16 kHz	256/128 samples	H
3,4	PAN11	16 kHz	256/128 samples	H
5	BAR33	16 kHz	256/16 samples	H
7	BAR33	16 kHz	512/256 samples	H
8	BAR03	16 kHz	512/512 samples	O
9	PANCO	16 kHz		
9	PANCO	16 kHz		
9	SLECO	16 kHz		
10	BARNEW/BAROLD	16 kHz	256/128 samples	H
11	BAROV	16 kHz	512/256 samples	H

(type of window: O=open window, H=Hanning window).

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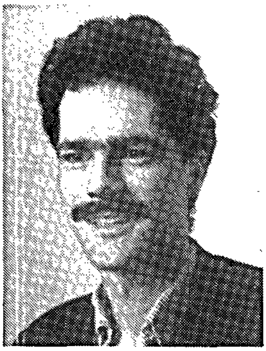
While writing this article we received the sad news that R. L. Martopangrawit had died april 13, 1986 (photo taken December 31, 1985 at his home in Surakarta).



JOS JANSSEN, gamelan musician and recording engineer, was born in Arnhem, the Netherlands, 18-5-1953 (The birthday of Russell and Carnap...). After studying at the music school in Arnhem and working as a recording engineer, he became interested in electronic (in particular computer music) and javanese gamelan music. In 1976 he started his studies at the Institute for Sonology and at the embassy of the Republic of Indonesia in the Hague. He has undertaken three study trips to Indonesia, the first in 1980, the second in 1981 and the third in 1985. He has had private lessons at the A.S.K.I.-Academy in Solo with numerous gamelan teachers and most notably with R. L. Martopangrawit with whom he has held many interviews. In 1980 he applied measurements to various genders in the Kraton of Surakarta. Since 1979 he has been involved in a gamelan project under the mentorship of Dr. Werner Kaegi. Together they have set up a special gamelan compiler for the MIDIM-system, the outcome of which has been shown via compositions, concerts and publications. Most notably the MIDIM concert of associative computer music, Utrecht, Jan. 1984 and the first concert of computer music at the A.S.K.I.-Academy in Solo, Java, Dec. 1985. He has been an assistant of Dr. Werner Kaegi since 1983 and together with Paul Goodman gave a MIDIM workshop at the Institute for Sonology for two years. He is a member of the MIDIM-Group.

HEINERICH KAEGI was born in 1961 (an extremely good vintage year) in Switzerland where he spent his earliest years. In 1971 he emigrated along with his parents to Holland. At the moment he is studying physics at the University of Utrecht and is specialised in the foundations of this science. His interests extend to the relations existing between the arts (in its widest sense), technology and science. For this reason aside from his academic studies he is intensively busy in the fields of theatre (acting, directing), literature, language and music (in particular sonology). He has a special love for nature whose fecundity inspires and forms a reference point for all artistic activity. As a member of the MIDIM-group he has taken an active part in the artistic experiments as well as the scientific research of the group.