Application of
Graph Grammars in
Music Composing Systems

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Some Historical Remarks to Music & Computers

At first sight music and computers are incompatible: on the one side intuition and inspiration, on the other "stupid automatism". But if we look back in history we see that musicians were interested in new technologies because they wanted to increase their possibilities of expression.

Well known examples are the "Adagio und Allegro für ein Orgelwerk in einer Uhr" KV 594 by Wolfgang Amadeus Mozart [Sche 77], which he composed in 1790 to be played on a mechanical organ, and the "Wellingtons Sieg oder Die Schlacht bei Vittoria" Opus 91, the "Battle Symphony", by Ludwig van Beethoven, which was performed in 1813 for the first time on an instrument called "Panharmonikon", a large and highly developed orchestron built by Mälzel, who also invented the metronome [Re 82].

An early example of automatic data processing in modern sense are the famous mechanical instruments such as pianos and organs built by Welte (lateron together with Mignon), beginning in 1876 [Bu 82]. (Remember that Hollerith made his famous invention in 1885! [Ra 82]) The instruments were driven by large perforated tapes. For instance a tape of 30 meters length and a width of 45 centimeters allowed 8 minutes playing time for an organ. Many famous artists like Max Reger, Camille Saint-Saens, and Ignaz Paderewski made recordings on such instruments which allow us to hear their interpretations in a much more better quality than the recordings on shellac records. In some composition the increased possibilities of these instruments like playing more than ten notes simultaneously or playing extremely fast were used. An example is the "Toccata Opus 40 No 1" by Paul Hindemith composed in 1926 [Schu 81].

Computer applications in music and music science started very early. The first paper was published 1949 by Bronson: "Mechanical Help in the Study of Folkson" [Bro 49, Li 70]. That is only five years after Mark I, the first programmable computer in the USA [Ra 82]. In the mid of the fifties the first computer compositions were made. An early example is the Illiac-Suite by L. Hiller and L. Isaacson [Hi 74 in Ko 74]. Many other composers like Cage, Xenakis, Barlow, Brun, etc. followed. Nowadays computers are applied in all musical fields. Among others there are sound generating and analysis, score editing, style analysis, education, etc.
In this paper, we shall describe a computer workstation for music composition. At first we shall point out the structural similarities between music scores and computer programs. Then we shall shortly sketch the history of the development of a very large music piece. We shall compare this process with the common software life cycle and show that both are very similar. This was our motivation to use the concepts of software development environments to design and implement a composition system. According to the structure of music, we shall use graphs to represent scores and certain graph grammars to specify the manipulations on the them. Graphs and graph grammars have turned out to be very valuable tools in the design of software development environments, too [ELS 87, Na 85]. In the end we shall shortly discuss an experimental implementation of such a composition system called COMES [DS 85, DSW 85].

Music Scores Regarded as Software for Instruments

The traditional music notation may be regarded as a specification or programming language for music players. Like computer programs, scores are a finite sequence of elementary statements which must follow a certain formal syntax. These elementary statements are to be executed or interpreted on a special, well defined processor system. The temporal execution sequence of the single statements is fixed by the position in the program, respectivly in the score. In contrast to common programming languages like Algol or Pascal, even traditional music notation provides a high grade of parallelism.

Beside this general common aspect there are many similar details in scores and programs.

The following example is the beginning of the first movement of the Ninth Symphony in D minor by Ludwig van Beethoven Opus 125 [Be 79].

![Fig. 1. Beginning of the first movement of Beethoven's Ninth Symphony](image-url)