

COMPUTER MUSIC AT UNIVERSITY OF PADOVA

James DASHOW - Giovanni DE POLI - Graziano TISATO - Alvisè VIDOLIN  
Computer Music Group, University of Padova - ITALY

Abstract

The paper describes the work in computer-music currently being carried out at the University of Padova.

Activity is concentrated into four major areas: acoustic and psychoacoustic research, musical theory research, realisation of original musical works, education and instruction.

The requirements and theoretical assumptions which form the basis of the system's overall structure are discussed, and the hardware-software organisation is described with particular reference to its ease of use and future potential.

## COMPUTER MUSIC AT PADOVA UNIVERSITY

JAMES DASHOW, GIOVANNI DE POLI, GRAZIANO TISATO, ALVISE VIDOLIN

COMPUTER MUSIC GROUP

C/O CENTRO DI CALCOLO DELL'UNIVERSITA' DI PADOVA  
VIA SAN FRANCESCO 11, 35100 PADOVA, ITALY.

SINCE 1974 WORK IN COMPUTER MUSIC AT THE UNIVERSITY OF PADOVA HAS BEEN CONCERNED WITH FOUR GENERAL FIELDS OF ACTIVITY  
ACOUSTIC AND PSYCHOACOUSTIC RESEARCH  
MUSICAL THEORY  
REALIZATION OF ORIGINAL MUSICAL COMPOSITIONS  
EDUCATION.

THE DEVELOPMENT OF THESE ACTIVITIES HAS BEEN DUE TO THE INTER-DISCIPLINARY COLLABORATION OF SCIENTIST AND MUSICIAN. AT THE SAME TIME, RESEARCH IN VOICE ANALYSIS-SYNTHESIS AND VOICE RECOGNITION IS CONTINUING IN A SIMILAR MANNER.

THE FOLLOWING CONCEPTS WERE CONSIDERED ESSENTIAL TO THE CONSTRUCTION OF AN EFFECTIVE WORKING SYSTEM

1. EASE OF USE OF AVAILABLE RESOURCES, EVEN BY USERS UNACQUAINTED WITH COMPUTER TECHNOLOGY
2. ADAPTABILITY FOR ANY PROJECT WITH SPECIAL REQUIREMENTS
3. SIMULTANEOUS UTILIZATION OF RESOURCES BY SEVERAL USERS IN DIFFERENT CENTERS
4. LISTENING TURN-AROUND TIME TO BE AS FAST AS POSSIBLE WITHOUT LIMITATION OF OPERATIONAL POSSIBILITIES
5. HIGH QUALITY FOUR-CHANNEL DIGITAL-ANALOG CONVERSION
6. USE OF SPECIAL LANGUAGES FOR REPRESENTING MUSICAL INFORMATION TO VARIOUS DEGREES OF ABSTRACTION

WITH THESE REQUIREMENTS AS GUIDE-LINES, A SYSTEM WITH FULLY INTEGRATED HARDWARE AND SOFTWARE IS UP AND RUNNING AT PADOVA THAT IS BOTH EASY TO USE AND FLEXIBLE IN APPLICATION.

### HARDWARE--

THE HARDWARE AT OUR DISPOSAL INCLUDES THE EQUIPMENT OF THE COMPUTER CENTER AT THE UNIVERSITY OF PADOVA WHICH IS NORMALLY USED FOR RESEARCH, EDUCATION AND ADMINISTRATIVE PURPOSES. THESE ARE

- 1 CENTRAL UNIT IBM 370/158, 2 M BYTES OF MEMORY (32 BIT WORD)
- 6 IBM 3350 DISK UNITS, 317 M BYTES
- 6 IBM 3330 DISK UNITS, 100 M BYTES
- 4 IBM 2400 TAPE DRIVES, 9 TRACKS
- 2 IBM 3705 CONTROL UNITS, 160 K BYTES

- 2 IBM 3272 CONTROL UNITS, FOR LOCAL TERMINALS
- 4 IBM 3270 VIDEO TERMINALS WITH LIGHT PEN
- 2 IBM 3780 BATCH TERMINALS
- 1 IBM 3777 BATCH TERMINAL WITH PRINTER, 1100 LINES/MINUTE, AND READER, 300 CARDS/MINUTE
- 1 IBM 1403 PRINTER, 1100 LINES/MINUTE
- 1 IBM 1403 PRINTER, 600 LINES/MINUTE
- 1 IBM 3525 CARD PUNCH, 200 CARDS/MINUTE
- 1 IBM 3505 READER, 1200 CARDS/MINUTE
- 1 CALCOMP 925/1036 PLOTTER
- 1 CALCOMP 656 PLOTTER
- AN IBM S/7 MINI-COMPUTER (FIG.1) HAS BEEN DEDICATED TO VOICE AND MUSIC RESEARCH, AND IS FURNISHED WITH
  - 16 K WORDS OF MEMORY (16-BIT WORD)
  - 2 DISKS, EACH WITH 1.25 M WORDS CAPACITY (16-BIT WORD)
  - CHANNEL ATTACHMENT THAT PERMITS MEMORY TO MEMORY TRANSMISSION AT 256 K BYTES/SEC FROM THE S/370 SYSTEM TO THE S/7
  - 12 12-BIT D/A CONVERTERS
  - 1 12-BIT A/D CONVERTER

IN ADDITION THERE IS AVAILABLE AT THE ELECTRONIC ENGINEERING DEPARTMENT A SYSTEM CONSISTING OF

- 1 NOVA 1200 JUMBO MINI-COMPUTER, 32 K WORDS MEMORY (16-BIT WORD) FURNISHED WITH
  - 1 TELETYPE ASR 33
  - 1 DOUBLE CASSETTE DRIVE UNIT
  - 1 ALPHA-NUMERIC VIDEO DISPLAY UNIT
  - 2 DISK DRIVES AND 1 DISK CONTROLLER
  - 1 CARD READER
  - 1 PRINTER
  - 1 16-CHANNEL 12-BIT A/D CONVERTER
  - 2 12-BIT D/A CONVERTERS
  - 1 TAPE DRIVE, 76 K WORDS/SEC, 800 BPI, 9 TRACKS, AND 1 CONTROLLER

#### SOFTWARE ORGANIZATION--

A PROGRAM FOR SOUND SYNTHESIS USES ALGORITHMS, USUALLY REFERRED TO AS INSTRUMENTS (5), WHICH ARE CALLED UPON TO PROCESS DATA, OR THE SCORE, FOR THE GENERATION OF WAVESHAPES IN TIME.

THE VARIOUS WAYS IN WHICH MUSICAL INFORMATION MAY BE REPRESENTED RESULT IN VARIOUS KINDS OF SCORES. WE DEFINE AN OPERATIONAL SCORE AS THE SUM OF ALL INFORMATION NECESSARY FOR SYNTHESIS, WHICH WILL CONSIST OF PARAMETERS RELEVANT TO THE ACOUSTICAL PROPERTIES OF THE SOUND AND PARAMETERS RELEVANT TO THE FUNCTIONING OF THE INSTRUMENT.

COMPOSING AT THE LEVEL OF THE OPERATIONAL SCORE CAN BE TEDIOUS

FOR THE MUSICIAN WHERE CERTAIN OF THE MORE MECHANICAL FUNCTIONS OF THE INSTRUMENT ARE NOT DETERMINED DIRECTLY BY THE MUSICAL IDEA. THE COMPOSER OFTEN SPECIFIES ONLY VARIOUS ACOUSTIC PARAMETERS BY MEANS OF A SYMBOLIC SCORE, GENERALLY GRAPHIC, WHOSE SYMBOLS DEFINE THE FUNDAMENTAL CHARACTERISTICS OF THE MUSICAL EVENTS. IT IS POSSIBLE AS WELL TO THINK OF A STRUCTURAL SCORE THAT NOT ONLY REPRESENTS THE ORGANIZATION OF AND RELATIONSHIPS BETWEEN MUSICAL EVENTS BUT ALSO CONTAINS THE ACTUAL PRINCIPLES OF COMPOSITION FOR EACH WORK.

OUR SYSTEM IS SET UP IN SUCH A WAY AS TO PERMIT THE COMPOSER TO WORK AT ANY OR ALL OF THESE THREE LEVELS OF SCORE DEFINITION, CLOSELY CONNECTED WITH EACH OTHER, IN THE COURSE OF A SINGLE PIECE. FIG. 2 ILLUSTRATES THE VARIOUS LEVELS OF MUSICAL INFORMATION REPRESENTATION AND THE PROGRAMS THAT ACTIVATE THEIR INTERCONNECTION. THE PROGRAMS ARE DESIGNED SO THAT IF THE COMPOSER IS WORKING ON A HIGHER LEVEL, FOR EXAMPLE AT THE STRUCTURAL SCORE LEVEL, HE MAY CHECK THE EVENTUAL TRANSFORMATIONS AND CONTROL THE RESULTS AT LOWER MORE SPECIFIC LEVELS.

THE LANGUAGE EXPRESSING THE INFORMATION AT EACH LEVEL IS ORGANIZED IN SUCH A WAY AS TO PERMIT THE SIMULTANEOUS EXISTENCE OF DIFFERENT LEVELS OF INFORMATION AND TO INTEGRATE ALL LEVELS INTO A SINGLE FUNCTIONAL UNIT. THUS THE SYSTEM OFFERS THE ADVANTAGES OF HIGHER LEVEL REPRESENTATION WITHOUT SACRIFICING THE POSSIBILITY OF PRECISELY DETERMINING SPECIFIC OPERATIONAL DETAILS.

#### AVAILABLE PROGRAMS--

##### -MUSIC

FOR BATCH SYNTHESIS IT WAS FELT THAT THE WELL-KNOWN PROGRAMS MUSIC5 (1), MUSIC360 (2), AND MUSIC4BF (4), OFFERED SUPERIOR ADVANTAGES PARTICULARLY WITH RESPECT TO POSSIBLE INTEGRATION FOR SIMULTANEOUS MIXED USAGE. TWO PROCEDURES HAVE BEEN DEVELOPED, MU45 AND MU54, THAT PERMIT THE SHARING OF DATA AMONG THESE PROGRAMS.

##### -ICMS

FOR INTERACTIVE SYNTHESIS THE ICMS (INTERACTIVE COMPUTER MUSIC SYSTEM) (6), HAS BEEN CREATED WHICH MAY OPERATE IN MULTI-PROGRAMMING ENVIRONMENT. THE SYSTEM FEATURES

- LOADING AND CONTROL OF OPERATIONAL PARAMETERS FROM A VIDEO TERMINAL IN A SIMPLE AND DIRECT MANNER
- REAL TIME SYNTHESIS
- ANALYSIS OF ACOUSTIC PROPERTIES OF THE GENERATED SOUNDS, AND IMMEDIATE VISUAL REPRESENTATION OF THE COMPLETE SPECTRUM FOR ANY MOMENT IN TIME
- MEMORIZATION AND RECALL OF ANY PREVIOUSLY CREATED OR DEFINED SCORE OR INSTRUMENT
- DIGITAL MIXING OF SELECTED MUSICAL MATERIAL
- OPTIONAL PRINTING OF ANY DESIRED INFORMATION (SCORE, SPECTRA,

INSTRUMENT PARAMETERS, ENVELOPE SHAPES, ETC.).

BECAUSE OF THE SIMPLICITY AND DIRECTNESS OF THE LANGUAGE USED, THE ICMS PROVIDES AN EASY INTRODUCTION TO COMPUTER MUSIC PARTICULARLY FOR NON-SPECIALISTS. THE SYSTEM HAS ALREADY BEEN SUCCESSFULLY USED FOR ACOUSTIC AND PSYCHO-ACOUSTIC RESEARCH AS WELL AS IN THE PRODUCTION OF MUSICAL WORKS AND FOR EDUCATIONAL PURPOSES.

#### -MUSICA

THE LANGUAGE MUSICA (3) PERMITS THE TRANSCRIPTION OF ANY MUSICAL TEXT WRITTEN IN ANY FORM OF TRADITIONAL STAFF NOTATION INTO AN ALPHA-NUMERIC CODE ISOMORPHIC TO THE ORIGINAL.

THE MAIN USE OF SUCH A PROGRAM IS FOR GENERATING AN OPERATIONAL SCORE FOR SYNTHESIS PROGRAMS BY MEANS OF A TRANSLATING PROCEDURE. THE LANGUAGE OFFERS THE FURTHER POSSIBILITY OF CODING ANY OTHER ALPHA-NUMERIC INFORMATION THE PURPOSE OF WHICH IS TO MODIFY THE TRANSLATOR PHASE AND TO IMPLEMENT FULLY THE OPERATIONAL SCORE (FOR EXAMPLE PERFORMANCE INSTRUCTIONS IN A REAL-TIME EXECUTION SITUATION).

#### -EMUS AND CELLE

EMUS ELABORATES MUSICAL STRUCTURES BY MEANS OF A STRUCTURAL SCORE. THE PROGRAM FEATURES THREE FUNCTIONS, NOT NECESSARILY SEQUENTIAL. THE FIRST DEFINES OR GENERATES SYMBOLICALLY BASED MATERIALS WITH VARIOUS METHODS NUMERICALLY, GRAPHICALLY, OR PSEUDO-ALEATORICALLY. THE SECOND FUNCTION ORGANIZES THE MATERIALS SO REALIZED INTO HIERARCHICAL STRUCTURES WHICH ARE THEN TEMPORALLY DISTRIBUTED ACCORDING TO THE COMPOSER'S REQUIREMENTS. THE THIRD FUNCTION TRANSLATES THE SYMBOLS CONTAINED IN THE TEMPORAL STRUCTURE INTO THE OPERATIONAL SCORE. THE COMPOSER MAY CONTROL EACH FUNCTION AT ANY POINT IN ORDER TO DETERMINE PRECISELY THE FINAL RESULTS WITHOUT HAVING TO WORK AT THE OPERATIONAL LEVEL.

CELLE IS CONCERNED EXCLUSIVELY WITH RHYTHMIC STRUCTURE ELABORATION. IT IS BASED ON PRINCIPLES ANALAGOUS TO THOSE OF EMUS, ALTHOUGH USING AN ENTIRELY DIFFERENT LANGUAGE.

#### -ANALYSIS PROGRAMS

BESIDES THE MORE SPECIFICALLY MUSIC PROGRAMS, THERE IS A GROUP OF PROGRAMS AND A GREAT DEAL OF KNOWLEDGE ABOUT ACOUSTICAL ANALYSIS THAT HAVE RESULTED FROM CONTINUING RESEARCH IN VOICE SYNTHESIS. THE VAI7 SYSTEM (VIDE, ASEQ, INTR) FOR THE INTERACTIVE ANALYSIS AND SEGMENTATION OF SOUND. ANALYSIS AND SYNTHESIS PROGRAMS BY LINEAR PREDICTION CODE TECHNIQUES (LPC). OTHER PROGRAMS FOR NUMERIC PROCESSING OF VARIOUS KINDS OF SIGNALS. FINALLY, THERE IS THE ANALYSIS SYSTEM TONEAN BY JAMES BEAUCHAMP WHICH FURNISHES A GRAPHIC REPRESENTATION OF THE SPECTRAL PROGRESS IN TIME OF ANY GIVEN SOUND.

#### SYSTEM ORGANIZATION--

ALL PROGRAMS ARE RUN FROM TIME-SHARING TERMINALS UNDER TSO

(TIME SHARING OPTIONS) MONITOR CONTROL. A GROUP OF COORDINATED COMMANDS HAVE BEEN CREATED TO ALLOW THE MUSICIAN TO RUN EASILY SEQUENCES OF PROGRAMS WITH AN OPERATIONAL CONSISTENCY. THESE COMMANDS EFFECT EXECUTION BY PLACING PROGRAMS UNDER CONTROL OF THE BATCH QUEUES OF THE VARIOUS AVAILABLE PARTITIONS. THIS PROCEDURE WAS PREFERRED TO TIME-SHARING SINCE AT OUR INSTALLATION IT GUARANTEES LESS WAITING TIME AND ABOVE ALL THE POSSIBILITY TO CONTINUE WITH OTHER JOBS AT THE TERMINAL WITHOUT HAVING TO WAIT FOR A PROGRAM TO COMPLETE EXECUTION.

THERE IS ALSO A CONTINUALLY EXPANDING LIBRARY CONTAINING FULLY DOCUMENTED SUBPROGRAMS, SCORES AND CATALOGUED INSTRUMENTS ALL OF WHICH ARE DIRECTLY AVAILABLE TO THE USER THROUGH THESE COMMANDS. WITH SIMILAR EASE THE ENTIRE SYSTEM OF COMMANDS AND LIBRARY MAY BE ACCESSED BY THE USUAL PUNCHED CARDS FROM ANY TERMINAL CONNECTED TO THE S/370. THUS SEVERAL PERSONS SIMULTANEOUSLY MAY UTILIZE THE ENTIRE COMPLEX OF PROGRAMS, EVEN FOR WIDELY VARYING APPLICATIONS, WITHOUT INTERFERENCE.

IN THE TESTING STAGE OF INSTRUMENTS, TIMBRES, SHORT SECTIONS OF PARTICULAR PIECES ETC. THAT REQUIRE MINIMAL EXECUTION TIME, IT IS IMPORTANT THAT THE VARIOUS SUPPORT OPERATIONS BE COMPLETED IN AS SHORT A TIME AS POSSIBLE SO THAT THE MUSIC SYNTHESIS PROGRAMS MAY BE USED EFFICIENTLY. CONSEQUENTLY TAPES ARE NO LONGER ACCEPTABLE BECAUSE OF THE SLOWNESS BOTH IN THEIR MANUAL SETTING-UP AND INHERENT IN THE FUNCTIONING OF THE UNIT ITSELF. THE MUSIC SERIES OF PROGRAMS HAVE NOW BEEN MODIFIED TO ALLOW WRITING OF THE SAMPLES TO BE CONVERTED DIRECTLY ON DISK UNITS, AND IN THIS WAY THE TOTAL WAITING TIME IS CONSIDERABLY REDUCED. FOR SIMPLE INSTRUMENTS TURN-AROUND TIME IS OFTEN NO MORE THAN THE ELAPSED TIME NECESSARY FOR SYNTHESIS. TAPES MAY STILL BE USED FOR COMPLETE LONG WORKS WHOSE VARIOUS PARTS HAVE ALREADY BEEN TESTED AND WHICH ARE TO BE PERMANENTLY PRESERVED IN DIGITAL FORM.

#### PRINCIPAL FIELDS OF ACTIVITY-

RESEARCH IS MAINLY DIRECTED TOWARDS SIGNAL PROCESSING WITH REFERENCE TO SOUND ANALYSIS AND SYNTHESIS AND THE FORMALIZATION OF MUSICAL LANGUAGES AND OF COMPOSITIONAL PROCEDURES.

SYNTHESIS ALGORITHMS ARE STUDIED AND UTILIZED FOR MUSICAL COMPOSITION (9), AND EFFORTS ARE MADE TO CATEGORIZE SOUNDS IN ORDER TO PROVIDE MORE SYSTEMATIC MEANS OF THEIR REFERENCE AND USE. RESULTS ARE IMMEDIATELY APPLIED TO PRACTICAL MUSICAL PROBLEMS AS WELL AS EDUCATIONAL ACTIVITIES.

EDUCATION IS ESSENTIAL IN PROVIDING KNOWLEDGE TO MUSICIANS WHOSE TRAINING NORMALLY DOES NOT INCLUDE ACQUAINTANCE WITH THE RELEVANT ASPECTS OF COMPUTER TECHNOLOGY. SINCE TEACHING IS DONE WITH GREATER EFFICIENCY AT A COMPUTER CENTER, COURSES, SEMINARS AND WORKSHOPS ARE OFFERED ON VARIOUS LEVELS DIRECTED MAINLY TOWARDS MUSICIANS, WHILE THE ELECTRONIC ENGINEERING DEPARTMENT OFFERS AN ANNUAL COURSE IN COMPUTER MUSIC FOR THOSE INTERESTED IN THE MORE

PURELY SCIENTIFIC ASPECTS OF THE FIELD.

IT IS WORTH NOTING THE FRUITFUL COLLABORATION OF THE UNIVERSITY OF PADOVA, THE POLLINI CONSERVATORY OF MUSIC AT PADOVA AND THE MARCELLO CONSERVATORY OF MUSIC AT VENICE, BOTH IN THE FIELD OF MUSICAL RESEARCH AND IN EDUCATION. THE COMPUTER MUSIC SYSTEM IS USED INTENSIVELY BY TEACHERS AND STUDENTS OF THE TWO CONSERVATORIES AS WELL AS BY GUEST COMPOSERS AND RESEARCHERS.

IT IS JUST THIS HIGHLY PRODUCTIVE UTILIZATION OF THE SYSTEM BY A WIDE VARIETY OF PEOPLE WHOSE PURPOSES GREATLY DIFFER THAT VERIFIES THE DECISIONS FOR AND CONSTRUCTION OF THE SYSTEM.

#### REFERENCES-

1. MATHEWS M.V., THE TECHNOLOGY OF COMPUTER MUSIC, 1969, M.I.T. PRESS, CAMBRIDGE, MASS.
2. VERCODE B., REFERENCE MANUAL FOR THE MUSIC360 LANGUAGE FOR DIGITAL SOUND SYNTHESIS, 1973, FROM THE AUTHOR, M.I.T., CAMBRIDGE, MASS.
3. DE BIASI GB. - DE POLI G., MUSICA A MUSICAL TEXT CODING LANGUAGE FOR COMPUTERS, PROC. FIRST INTERNATIONAL COMPUTER MUSIC CONFERENCE, OCT. 1976, M.I.T., CAMBRIDGE, MASS., (IN PRESS).
4. HOWE H.S., ELECTRONIC MUSIC SYNTHESIS CONCEPTS, FACILITIES, TECHNIQUES, 1975, DENT & SON (G.B.), NORTON (U.S.A.)
5. DE POLI G. - VIDOLIN A., COMPUTER MUSIC PROPOSTE PER UNA IMPOSTAZIONE PROCEDURALE, 1975, ATTI DEL III E IV SEMINARIO DI STUDI E RICERCHE SUL LINGUAGGIO MUSICALE, ISTITUTO MUSICALE F. CANNETI, VICENZA
6. TISATO G., AN INTERACTIVE SOFTWARE SYSTEM FOR REAL-TIME SOUND SYNTHESIS, 1976, PROC. FIRST INTERNATIONAL COMPUTER MUSIC CONFERENCE, OCT. 1976, M.I.T., CAMBRIDGE, MASS., (IN PRESS).
7. DE POLI G. - VIDOLIN A., CELLE UN PROGRAMMA PER L'ELABORAZIONE DI STRUTTURE RITMICHE MUSICALI, 1976, ATTI DEL VI SEMINARIO DI STUDI A RICERCHE SUL LINGUAGGIO MUSICALE, ISTITUTO MUSICALE F. CANNETI, VICENZA (IN PRESS).
8. DE POLI G. - VIDOLIN A., EMUS UN PROGRAMMA PER L'ELABORAZIONE DI STRUTTURE MUSICALI, 1977, ATTI DEL PRIMO COLLOQUIO SU ASPETTI TEORICI DI INFORMATICA MUSICALE, MILANO
9. DASHOW J., THREE METHODS FOR THE DIGITAL SYNTHESIS OF CHORDAL STRUCTURES WITH NON-HARMONIC PARTIALS, 1977, (TO BE PUBLISHED BY INTERFACE MAGAZINE, JUNE 1978, UTRECHT)