COMPOzE
Intention-based Music Composition through Constraint Programming

TAI 1996

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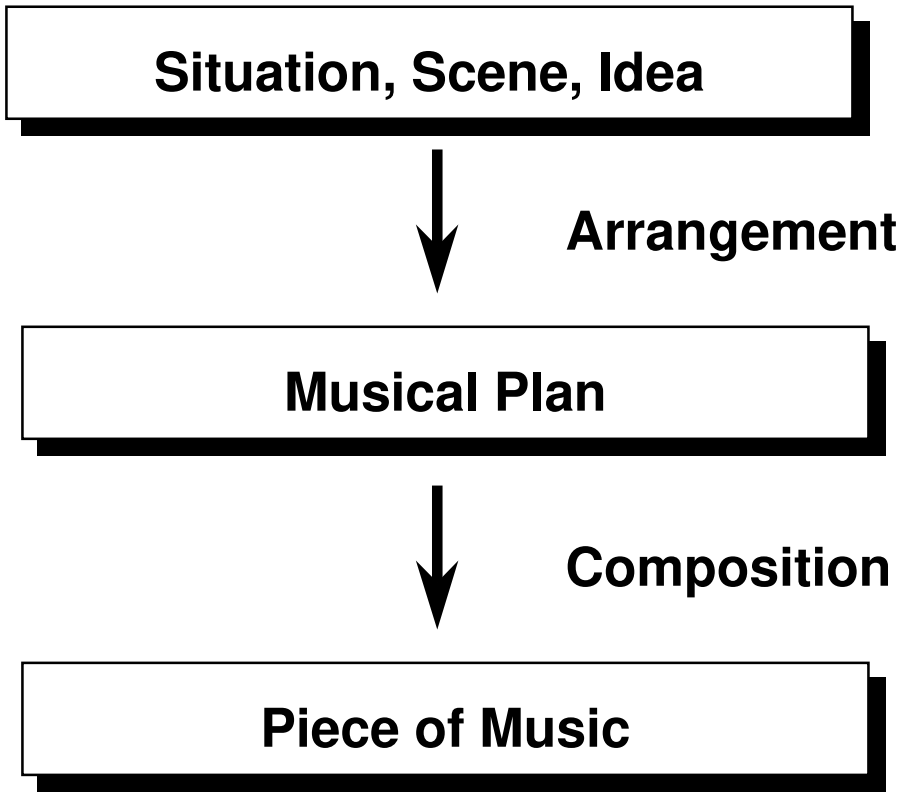
http://www.ps.uni-sb.de/~henz/oz/COMPOzE/

Overview

1. Intention-based Composition
2. Musical Background
3. Composition as Constraint Satisfaction
4. Constraint Programming
5. The Tool COMPOzE

1. Intention-based Composition

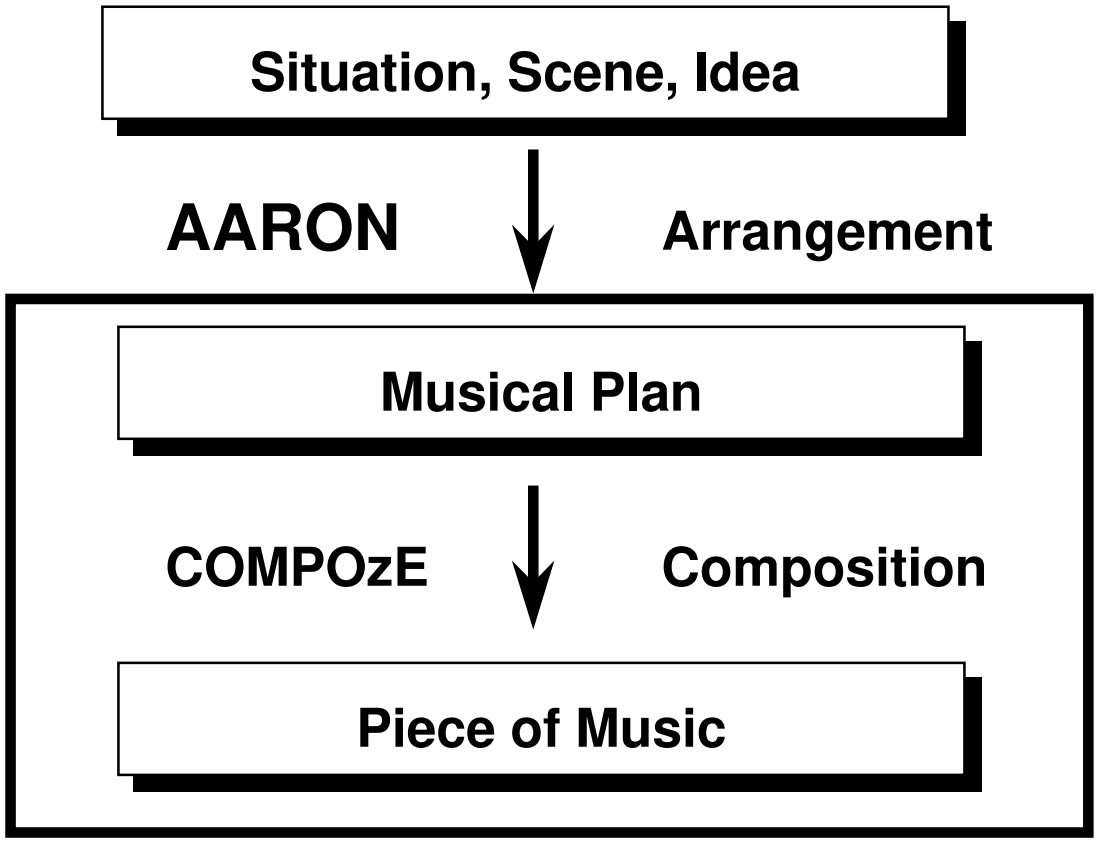
General Setup



Applications

- multimedia presentations
- music accompanying documentary films
- telephony
- musical web pages

Focus


Situation, Scene, Idea
AARON
Arrangement
Musical Plan
COMPOzE
Composition
Piece of Music

Related Work

- Jazz Improvization [Johnson-Laird, 91]
- CHORAL [Ebcioglu, 92]
- Constraints and Objects [Pachet and Roy, 95]

Key Issues

- configurability
  - musical rules
  - solution strategies
- interactivity
  - experimentation by direct manipulation
  - anytime optimization
- media
  - visualization of search process
  - accoustic output

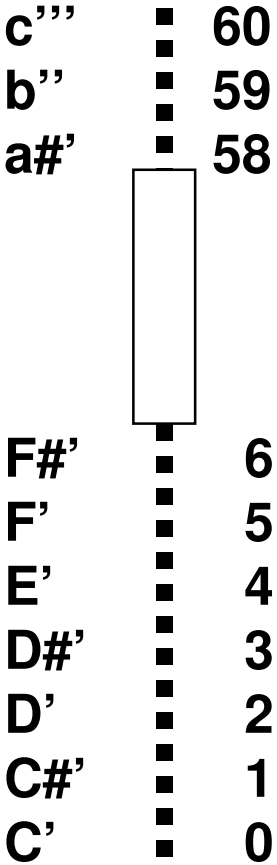
Key Technology

Constraint Programming

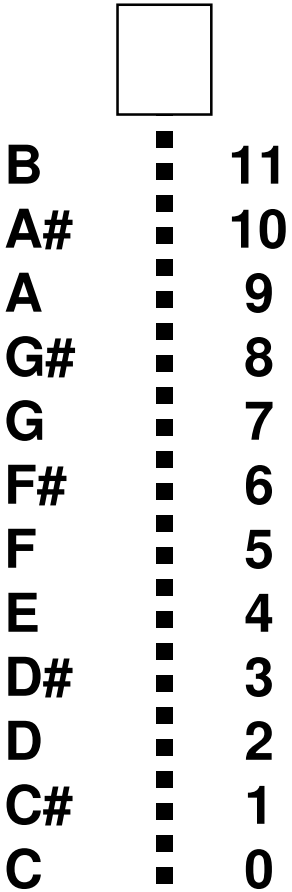
2. Musical Background

Basics

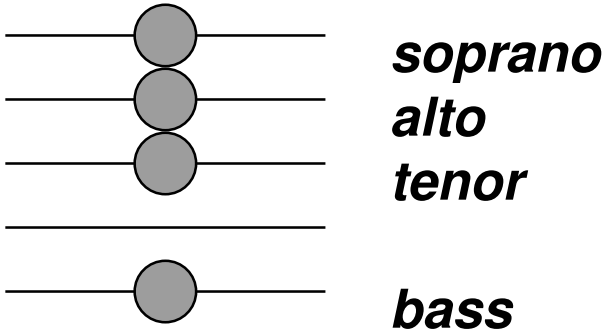
Pitches



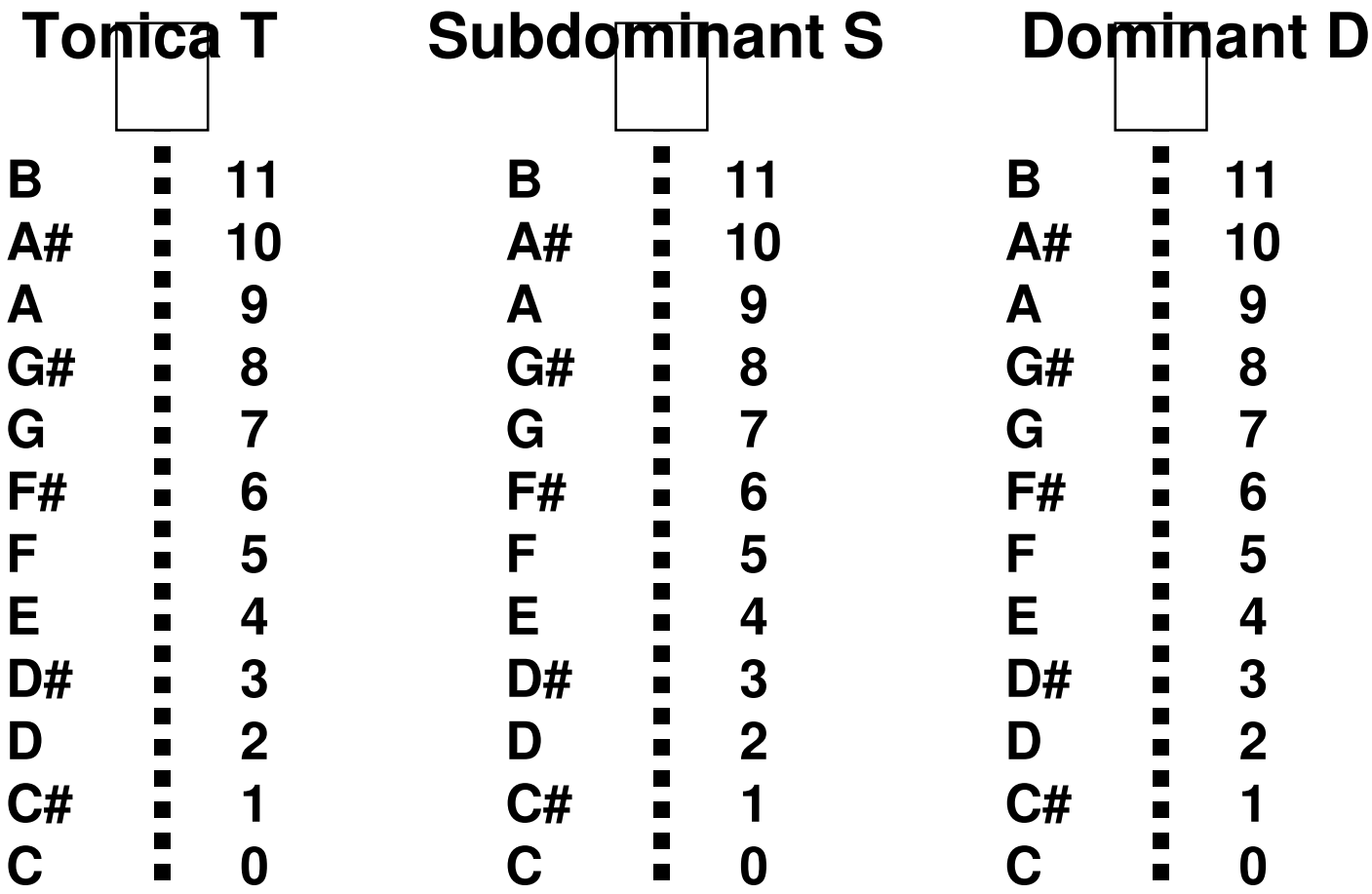
Tones



Chords



Harmonic Functions



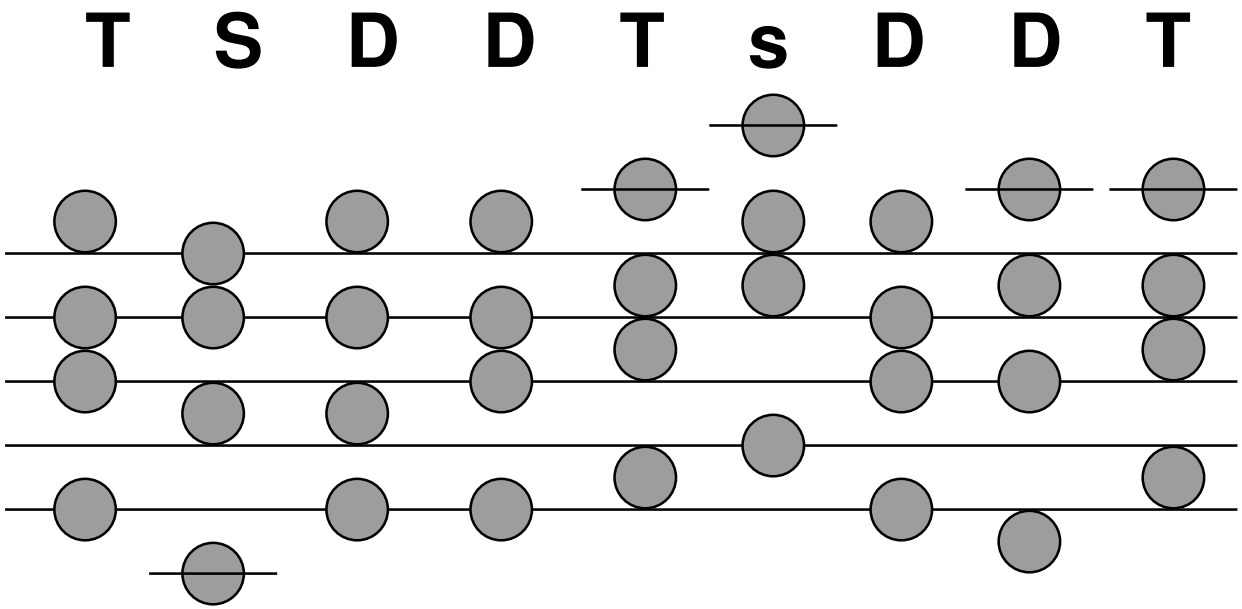
Input

Harmonic Progression

T S D D T s D D T

Input

Harmonic Progression



Four Voice Composition

Output

Composition Rules

- **Pitch Rules**
  - ambitus
- **Chord Rules**
  - crossing prohibition
  - bass distance
- **Sequence Rules**
  - jump compensation
  - bass figuration

3. Intention-based Composition as Constraint Satisfaction Problem

Constraint Satisfaction Problem

- **Variables**

  $4 \cdot n$ variables B_i, T_i, A_i, S_i, $i \in \{1,\ldots,n\}$

  - **ranging over integers** $\{0,\ldots,60\}$

❑ Constraints

- **harmonic functions:** $B_i \mod 12 \in \{0,4,7\}$
- **ambitus:** $\forall_i \; 0 \le B_i \le 20$
- **bass distance:** $\forall_i \; B_i + bassDist \le T_i, A_i, S_i$
- **jump compensation:**

$$\forall_i \quad S_i - S_{i+1} \ge jump \rightarrow S_{i+2} - S_{i+1} \in \{1,2\}$$

$$S_{i+1} - S_i \ge jump \rightarrow S_{i+1} - S_{i+2} \in \{1,2\}$$

4. Constraint Programming

Constraint Propagation

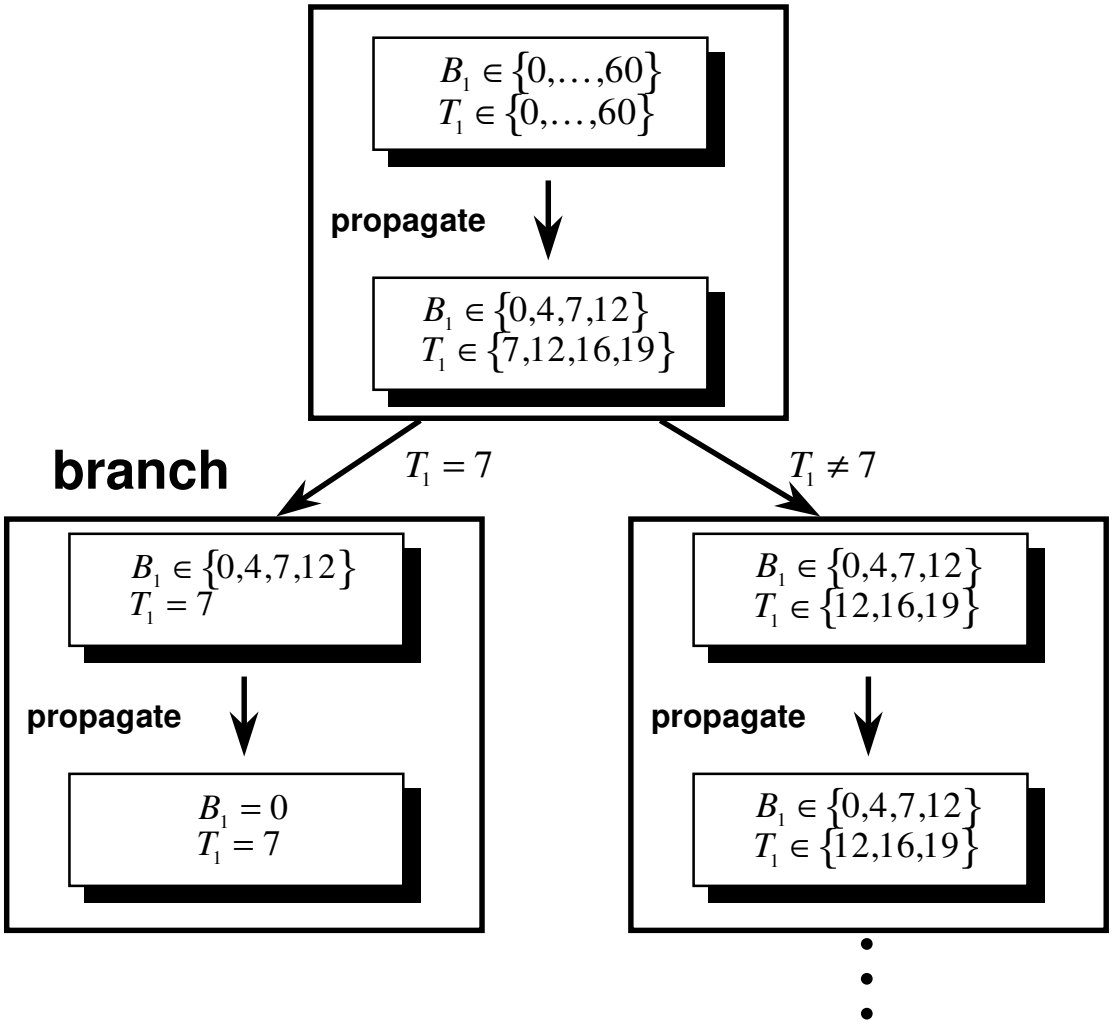
$$B_1 \in \{0,\ldots,60\}$$
$$T_1 \in \{0,\ldots,60\}$$
$$bassDist = 6$$

propagate ↓

$$B_1, T_1 \bmod 12 \in \{0,4,7\}$$
$$0 \le B_i, T_i \le 20$$
$$B_1 + bassDist \le T_1$$

$$B_1 \in \{0,4,7,12\}$$
$$T_1 \in \{7,12,16,19\}$$
$$bassDist = 6$$

Search


$B_1 \in \{0,\ldots,60\}$
$T_1 \in \{0,\ldots,60\}$
propagate
$B_1 \in \{0,4,7,12\}$
$T_1 \in \{7,12,16,19\}$
branch
$T_1 = 7$
$T_1 \neq 7$
$B_1 \in \{0,4,7,12\}$
$T_1 = 7$
propagate
$B_1 = 0$
$T_1 = 7$
$B_1 \in \{0,4,7,12\}$
$T_1 \in \{12,16,19\}$
propagate
$B_1 \in \{0,4,7,12\}$
$T_1 \in \{12,16,19\}$

Advanced Constraint Programming Techniques

- variable selection
  - first fail
  - most constrained first
- soft constraints through branch-and-bound optimization

Role of Constraint Programming Environment

- provides propagation and search engine
- allows flexible variable and value selection
- visualizes search
- allows inspection of constraints during search

5. COMPOzE, the Tool

The Constraint Programming Environment DFKI Oz

- performance comparable to commercial CP systems
- full fledged programming environment including programming interface, graphics and interoperability libraries
- unrivaled constraint programming tools

DFKI Oz is developped in
Programming Systems Lab
Director: Gert Smolka
http://www.ps.uni-sb.de/oz

Summary

- Intention-based Composition as Constraint Satisfaction Problem
- Constraint Programming provides adequate Tools
- Oz as Constraint Programming Environment