Descriptor Synth: Action & Goal Plan (Extended)

SYNTHESIS SYSTEM: GOAL OVERVIEW

This synthesis engine is organized around 2 MAIN AXES:

1. TEMPO (Temporal structure how sound evolves over time)

2. FREQUENZE (Spectral structure how sound energy is distributed across frequencies)

All parameters are mappable via GUI controls (sliders, toggles, curve editors, or modifiers).

Total descriptors to implement: 28

AXIS 1: TEMPO Temporal Control (8 items)

[1] Attack (Att): Time for the sound to rise from silence to peak level.

[2] Decay (Dec): Time to transition from peak to sustain level.

[3] Sustain (Sus): Level maintained after decay until note is released.

[4] Release (Rel): Time it takes for the sound to fade to silence after release.

[5] Temporal Centroid (TempCent): The "center of gravity" of energy over time.

[6] Autocorrelation: Measures signal periodicity, useful for detecting rhythm.

[7] Zero Crossing Rate: Number of times the signal crosses zero amplitude per time unit.

[8a] Energy Modulation Amplitude: Strength of amplitude modulation (tremolo-like effect).

[8b] Energy Modulation Frequency: Rate at which amplitude modulation occurs.

GOALS:

- Distribute total Frame Energy (FrameErg) over time using the ADSR envelope and TempCent.

- Allow energy shaping curve selector (e.g., Gaussian, Linear, Exponential).

- GUI: sliders or curves for ADSR, TempCent; selector for distribution type.

AXIS 2: FREQUENZE Spectral & Harmonic Control (20 items)

SPECTRAL DESCRIPTORS (11):

[9] Spectral Centroid (SpecCent): "Brightness" weighted average frequency of the spectrum.

[10] Spectral Spread (SpecSpread): Bandwidth around the centroid how wide the spectrum is.

[11] Spectral Skewness (SpecSkew): Asymmetry of energy distribution (bias to high/low frequencies).

[12] Spectral Kurtosis (SpecKurt): Peakedness or flatness of the spectral shape.

[13] Spectral Decrease (SpecDecr): Rate of energy decay from low to high frequencies.

[14] Spectral Flatness (SpecFlat): Whether the spectrum is flat (like noise) or peaked (like tones).

[15] Spectral Crest (SpecCrest): Ratio of peak to average energy indicates tonal peaks.

[16] Spectral Slope (SpecSlope): General direction of energy flow across frequency (tilt).

[17] Spectral Variation (SpecVar): Change in spectral shape over time smooth or erratic.

[18] Spectro-temporal Variation: Combination of frequency and time variation.

[19] Spectral Shape (General): Overall geometry of the spectral envelope.

HARMONIC STRUCTURE DESCRIPTORS (9):

[20] Fundamental Frequency (F0): The lowest frequency of a periodic sound.

[21] Harmonic Energy (HarmErg): Energy contained in harmonic (periodic) components.

[22] Noise Energy (NoiseErg): Energy in non-harmonic (noisy) components.

[23] Noisiness: Difference between FrameErg and HarmErg amount of noise.

[24] Inharmonicity (InHarm): Degree of deviation from a perfect harmonic series.

[25] Harmonic Spectral Deviation (HarmDev): Variation of harmonic/noise balance over time.

[26] Odd to Even Harmonic Ratio (OddEveRatio): Strength of odd-numbered harmonics vs even ones.

GOALS:

- For each window: distribute FrameErg using SpecCent as peak, SpecSpread as bandwidth.
- Shape the spectrum with SpecSkew, SpecKurt, SpecDecr, and SpecFlat logic.
- Control the number of tonal peaks with SpecCrest.
- Introduce time-variation with SpecSlope, SpecVar.
- Harmonic logic:

Allocate % of FrameErg to harmonics (based on F0), rest to NoiseErg (Noisiness).

InHarm adjusts deviation from ideal harmonics.

HarmDev adjusts balance between harmonic and noise components over time.

OddEveRatio defines harmonic spectral shape.

IMPLEMENTATION FLOW

Step 1: Define 5 time markers:

- Attack, Decay, Sustain, Release, Temporal Centroid

Step 2: Divide FrameErg across time using selected temporal distribution (Gaussian, etc.)

Step 3: For each time window:

- Assign temporal energy
- Evaluate spectral and harmonic descriptors
- Distribute energy in frequency accordingly

Step 4: Render sound offline (e.g., via Pyo, TorchAudio, or NumPy-based synthesis)

GUI REQUIREMENTS

- All 28 descriptors are controllable via:

Sliders (e.g., Attack, Spectral Skew)

Curve Editors (e.g., Spectral Centroid over time)

Toggles (e.g., SpecFlat)

Dropdown selectors (e.g., Gaussian vs Linear distribution)

CORE DESCRIPTORS TO PRIORITIZE IN MVP

1. Frame Energy (FrameErg)

2. Spectral Centroid (SpecCent)

3. Spectral Variation (SpecVar)

4. Fundamental Frequency (F0)

5. ADSR: Attack, Decay, Sustain, Release

6. Temporal Centroid (TempCent)

CHECKLIST SUMMARY

8 Temporal Descriptors

11 Spectral Descriptors

9 Harmonic Descriptors

= 28 implemented GUI-controllable parameters

Final Goal:

A system capable of morphologically shaping sound by mapping descriptor curves to synthesis parameters, rendered offline.