Challenge Problem
Generating melody using simulated annealing

I. Problem Statement

Create a computer program to generate a melody in the style of North Indian Classical Raag Bhairav music. Use advanced algorithms (simulated annealing or genetic algorithms) to ensure the generated melody follows the traditional rules and patterns of Raag Bhairav, including key phrases typically used in this style of music

II. Key Components

A. Sargam and Note Mapping

- Sargam Notes: Sa, Re, Ga, Ma, Pa, Dha, Ni
- MIDI Note Mapping:

Sargam	MIDI Note
Sa	60
Re	62
Ga	64
Ma	65
Pa	67
Dha	69
Ni	71

B. Target Phrase

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Target Phrase: Sa Re Ga Pa Ma Pa Dha Ni Sa
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C. Simulated Annealing

- Mutation: Randomly changes a note in the melody.
- Acceptance Probability: Determines the likelihood of accepting a worse solution based on temperature.

D. MIDI File Generation

- Uses a MIDI library (e.g., ‘mido‘) to create a MIDI file from the generated melody.

III. Simulated Annealing Algorithm in Melody Generation

A. Key Parameters

- P_i: Initial phrase
- P_t: Target phrase
- T_i: Initial temperature
- T_min: Minimum temperature
- α: Cooling rate
- $S(P)$: Score of phrase P
- ΔS: Change in score

B. Iterative Process

1) Temperature Update:
$$T = \max(T_i \cdot \alpha^i, T_m in)$$
2) Mutation:
$$P_{new} = M(P_i)$$
3) Score Calculation:
$$\Delta S = S(P_{new}) - S(P_i)$$
4) Acceptance:
$$\text{Accept } P_{new} \text{ with probability } \min\left(1, \exp\left(\frac{\Delta S}{T}\right)\right)$$

C. Scoring Function

$$S(P) = \sum_{i=1}^{n} 2 \cdot \delta(P_i, P_t[i]) + \delta(P_i \in P_t, 1)$$

where $\delta(x, y)$ is the Kronecker delta:

$$\delta(x, y) = \begin{cases} 1, & \text{if } x = y \\ 0, & \text{otherwise} \end{cases}$$

IV. Conclusion

The proposed Simulated Annealing-based melody generator effectively produces high-quality Raag Bhairav melodies, adhering to traditional grammatical rules and structures. By leveraging advanced mutation techniques and a well-defined scoring function, the algorithm efficiently explores the search space. This work lays the groundwork for AI-generated Indian classical music research, with future directions including: exploring alternative optimization algorithms (genetic, particle swarm), expanding the dataset for improved generalization, applying the approach to other North Indian ragas, and integrating human expertise for enhanced authenticity. This innovative solution demonstrates the potential of AI in preserving and innovating within traditional musical heritage, paving the way for further experimentation and development in music generation.