Conceptual Space and Vector Representation

Project Objectives:

The project aims to develop an approach to understand and analyze transformations within the MIU system, moving from a string-based representation (semantic space) to an analogous conceptual space. Specific objectives include:

1. **Vector Representation:** To represent MIU transformations (or the relationship between an initial string and a target string) as vectors in a multidimensional mathematical space.
2. **Characteristic Inference:** To use this vector space to infer characteristics of transformations (such as "ease" or "probability" of reachability) without the need for exhaustive exploration of the entire MIU state space.
3. **Vector Analogies:** To leverage the structure of the vector space (distances, angles between vectors) to identify and visualize "analogies" between different transformations.
4. **Analogous Conceptual Space:** To construct a space where the geometric relationships between vectors (distances and directions) significantly reflect the underlying "similarities" or "conceptual relationships" of the transformations themselves.

Construction of Vector Representation:

For each transformation from an initial string (sinitial) to a target string (starget), obtained through a sequence of MIU rule applications, a vector v is proposed with the following components:

v=(Number of steps Levenshtein Distance(sinitial,starget) Count of Rule 1 (ends with ’I’ -> add ’U’) Count of Rule 2 (’Mx’ -> ’Mxx’) Count of Rule 3 (’III’ -> ’U’) Count of Rule 4 (’UU’ -> eliminate) Time taken for search (optional))

This vector v represents a point in a 7-dimensional vector space (or fewer, if the time component is omitted or handled differently). Each point in this space describes a specific transformation relationship between two MIU strings.

Vector Directions and Conceptual Similarities

Regarding the intuition that vector directions might reflect underlying conceptual similarities or relationships between transformations, this is a fundamental and desirable intuition for the construction of an analogous conceptual space.

Reasoning Behind this Intuition:

The construction of the vector v is intrinsically designed to capture aspects of transformations that we consider semantically or conceptually significant.

- **Proportional Components:** If two transformations are "similar" in their effect (e.g., both increase the string length by a similar amount and proportionally use the same rules), the

components of their respective vectors v will be proportionally similar. Vectors with proportional components tend to point in the same direction in the vector space.

- **Reflection of Characteristics:** Each component of the vector is a direct metric of a transformation characteristic (number of steps, structural distance, frequency of specific rule usage, computational cost). Therefore, "similarity" in these characteristics directly translates into "proximity" or "alignment" of vectors in the space. For example, transformations that are conceptually "expansive" (significantly increase length) and rely on Rule 2 ('Mx' -> 'Mxx') will have high values for the length and Rule 2 count components, and will tend to cluster and point in similar directions.

Evidence and Validation:

At the current stage, the correspondence between vector directions and conceptual similarities is an **intentional construction** based on the choice of vector components. To substantiate this intuition with empirical evidence, it will be necessary to:

1. **Generate Data:** Acquire a significant number of v vectors from various MIU transformations (or reachable string pairs).
2. **Spatial Analysis:** Analyze the distribution of these vectors in the multidimensional space.
3. **Correlation:** Seek correlations between vector "proximity" (measured via angles between vectors or Euclidean distances) and similarities that can be identified at a more intuitive or structural level of the strings and applied rules.

In summary, your intuition is correct: the vector's structure is designed to ensure that directions reflect conceptual similarities. The validation of this hypothesis will occur through the analysis of the data that will be generated.