Re-Generating Continuous Rumî Compositions

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Abstract

Rumî is the name of a motif which can be seen in traditional Turkish decorative arts, such as tilings, window lattices, locks, book bindings, plates, rugs, and fabrics. There are many different composition styles in which rumî motifs are used. We focus on a special style called continuous rumî compositions. First, we introduce a historical background of the motif, explaining its zoomorphic and shamanistic roots, and the fundamental transformations of the post-Islamic era. Then, we determine the geometric underpinnings and construction steps of abstract rumî compositions. Finally, we present a computer program which is used to generate new designs based on our studies.

Background

Rumî is the name of a motif which can be seen in traditional Turkish decorative arts. The rumî motif consists of a bulbous, round shape with a comma-like body attached to the pointed end (Figure 1). Although rumîs look like stylized leaves, they have zoomorphic origins [1],[2],[3],[7],[8],[9]. This origin makes rumî distinct from similar motifs with vegetative origins, such as "Yaprak", "Penç" and "Hatâyî"
.

Figure 1: *Examples of plain rumî motifs.*

Animals influenced the artists and shamans of early Turkish tribes living at the steppes of Central Asia. The animal forms represented strength, fertility, and an endless struggle of evil and good. Oldest known rumî-like animal shapes were discovered on rugs and fabrics found at southern Siberia, dated back to 4th century B.C. [5]. However, the earliest examples of complete rumîs are dated to 8th and 9th-century frescoes of Uyghur Turks [3],[8],[9]. In these frescoes, rumîs can be seen at the wings of sea creatures [3]. Rumîs were created from stylized animal figures, such as birds, lions, deer, fish, and fictional creatures such as dragons and Sîmurg (Figure 2). The Tai-Chi figure has a controversial connection with rumî, both formally and semantically [2], exemplifying a mutual influence between ancient Chinese and Turkish arts [6].

Rumîs can also be seen in many other communities such as Huns, Karahan, Ghazni, Abbasi, Andalusian and Fatimians [9]. Seljuk Turks, who migrated from Central Asia, brought the motif to Anatolia and gave its name. During the period of the Eastern Roman Empire, the Anatolian peninsula was called "Diyar-ı Rum", and the Seljuk Turks who had migrated from Asia were called Roman Seljuks [3],[5],[9]. This is why, rumî means Anatolian, or belongs to Anatolia [2],[3],[9]. Rumî is used extensively by Anatolian Seljuks between 11th and 14th centuries, in window lattices, gablets, locks, tilings, book bindings, plates, rugs, and fabrics. After Seljuks, Ottomans continued to use and further developed the motif.

Figure 2: *A brief evolution of the pre-Islamic rumî motif. Redrawn by the authors after [8].*

One can easily recognize animal figures in rumîs which are dated earlier than 14th century [2],[9]. However, these were transformed into abstract ornaments, when nomad Turks were converted to Islam and settled in cities either willingly or forcibly [5],[9]. After 15th century, rumî became a totally abstract shape, formally lost its zoomorphic roots and shamanistic meaning. It became a representation of the universal balance of God. This is the final stage of the historical development of rumî, perfected as a unique ornamental style [2],[7]. In the following centuries, rumîs are created only in this way. Figure 3 shows a classic example of a post-Islamic rumî composition. In this study, we focus on the geometric properties of the rumîs of the post-Islamic period.

Figure 3: *An example of post-Islamic rumî composition. 16th-century İznik tile; Gulbenkian Foundation Museum, Lisbon, No:821. Redrawn by the authors after [5].*

Although there are many books and researches on the historical and cultural origins of the motif, its geometric underpinnings are rather underrecognized. Most of the sources explain some general rules of rumî compositions. However, there is no mathematical explanation for it. In this paper, we analyze the geometric construction of rumî compositions and present an algorithm to re-create rumî-like designs. The scope of below study is limited to a special type of rumî composition called "sürgit" (Figure 3). There are rotational symmetry and continuity in sürgit compositions. This is why we will call this type of rumî compositions as "continuous rumîs".

Analysis

General construction steps of a classical rumî composition can be explained in several steps [7];

- Definition of the boundary,
- Drawing the reference circles ("Şebeke"),
- Drawing paths with directions,
- Placement of rumî motifs on the paths,
- Detailing the motifs (i.e. bifurcation of the motifs and adding smaller details).

Figure 4 shows the geometric components of a classical rumî composition. Most of these components are not unique to rumî styles but represents some of the common components and principles of classical ornaments [4]. For more drawings about the origins and the components of rumî compositions, readers are referred to [1],[2],[5],[8] and [9].

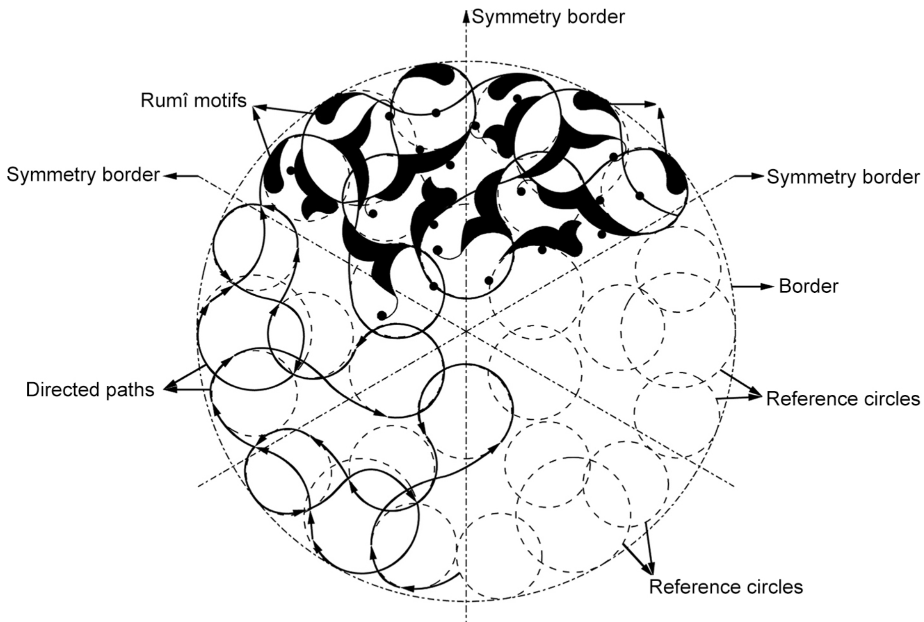

Figure 4: *Components of a rumî composition shown on the example at Topkapı Palace Museum Archives Nr. H2153-90a. Reconstruction and diagram by the authors after [5]. Rotational symmetry error*

Boundary ("Sınır")

The boundary of a rumî composition can be a strip, a polygon, a circle or another shape, depending on the subject, where the composition is created. Rectangle boundary is generally used in book covers while mosque minbars require triangular boundaries. The shape of the boundary helps to define construction method and symmetry axes of the composition. In continuous rumî compositions, boundaries are generally circular, and they contain rotational symmetry.

Reference Circles ("Şebeke")

"Şebeke" (Lattice) is the underlying system of circles which are used to construct the compositions. Most of the sources denote these reference circles as dashed lines. In continuous rumî compositions, distribution of the reference circles and their radii determine the visual balance of the composition, together with the rotational symmetry applied to them.

The Path ("Helezon")

Usually, rumî motifs are placed on curved paths. These paths are called "helezon" (spiral) or "dal" (branch) [7]. The path can be drawn by using the reference circles. First, the order of the reference circles is determined. It should often skip the nearest circles in order to create a complex and circuitous path. Then, a path curve moves around these circles, being partially tangent to them, and connecting them by following the order. The path has a direction, which is generally indicated by small arrowheads drawn on the curve. In continuous rumî compositions, the end point of one piece of the path should be the starting point of another. Thus, when the rotational symmetry is applied, the complete path becomes continuous without any endpoint. In some cases, the composition can include other (i.e. vegetative) motifs or text. If this is the case, rumî motifs are always drawn on separate paths, not sharing their path with other motifs [7].

Rumî Motifs

Rumîs are placed on the path curve by generally depending on two conditions: A rumî is placed on the path where the curvature is high, or there is an intersection point where the path is looping and intersecting with itself. Rumî is a directed motif, which means that the placement is related to the direction of the path curve [4]. In Figure 4, we see two basic types of rumî motifs and their placement rules. Single rumîs are placed on the path where there are high curvatures and are always placed on the interior side (at the same side with the oscillating circle). Two-fold motifs are placed on the intersection points.

There are several rules on the drawing of the rumî motif. The half-circle at one end of the motif is called “badem” (almond). After this half-circle is drawn, it is connected to the path with a curve that is tangent to the path and the almond at the same time. In the last step, the details are added to the motifs [7]. The simplest form of the motif is called “sade” (plain). There are many different types of rumîs named according to their forms, such as “sarılma rumî” (intertwined), “kanatlı rumî” (two-fold, or winged), “dendanlı rumî” (detailed), “hurde rumî” (nested), “ortabağ rumî” (middle knot), “üç iplik rumî” (three-fibers), “ayırma rumî” (separating) … etc. (Figure 5)

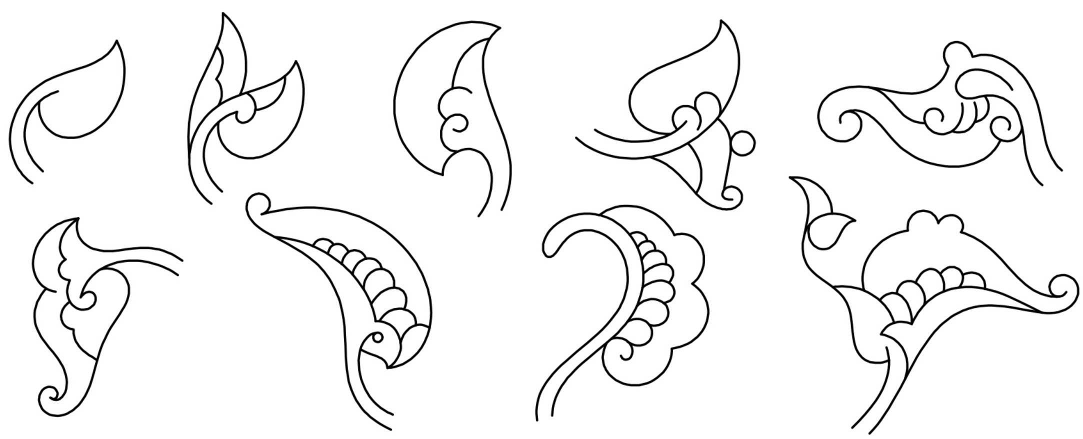

Figure 5: *Various types of rumî motifs.*

The Parametric Definition

In this study, we used a construction technique which is similar to the traditional one described above, but with several differences, in order to establish a mathematical background and parametric modeling workflow. Our parametric modeling starts with the definition of a coordinate system (a plane with an origin point). Instead of drawing the reference circles and then paths, we simply position and orient arcs that will form the circular portions of the path. Then, we blend these arcs to create the full path. Finally, the simplest form of the motif, the plain rumî will be drawn on the paths. Below is the step-by-step explanation of our construction process.

Drawing the Arcs of the Path

The standard parametric definition of an arc is given by;

$$x = f(t) \qquad y = g(t) \qquad \alpha \leq t \leq \beta$$

In our case, we define;

$$f(t) = a + r * \sin(t) \qquad g(t) = b + r * \cos(t)$$

In which the point (a,b) will be the center point of the arc and *r* is the radius. Figure 6 illustrates this.

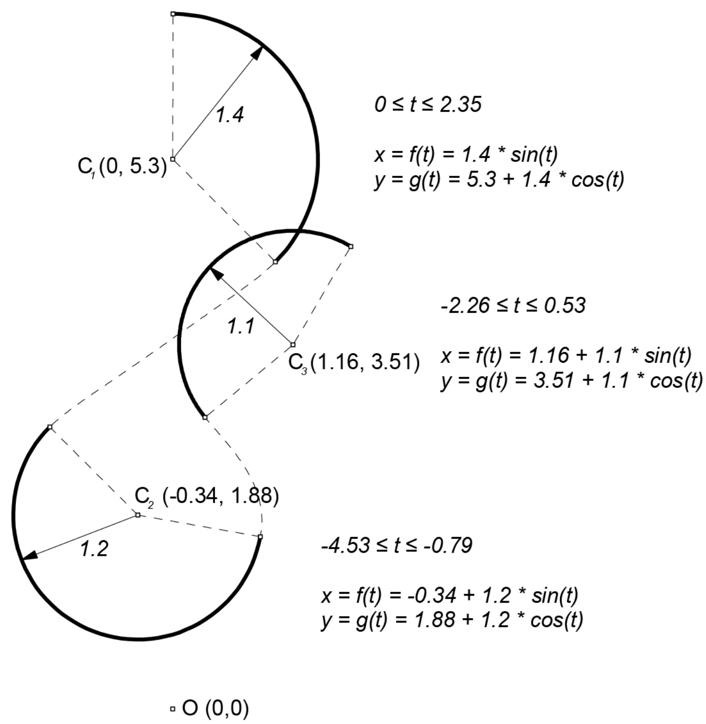

Figure 6: *Parametric definition of the arcs, including center points, radii, and angle domains.*

Order of the Arcs and Blending

In order to complete the path of rumî, the arcs defined in the previous step should be joined and blended. It is important to define the order of this process. The blending operation uses G^2 continuity (Figure 7). This type of geometric continuity joints the edges of the arcs by keeping the first and second derivatives proportional. A piece of the path is finished by blending the arcs.

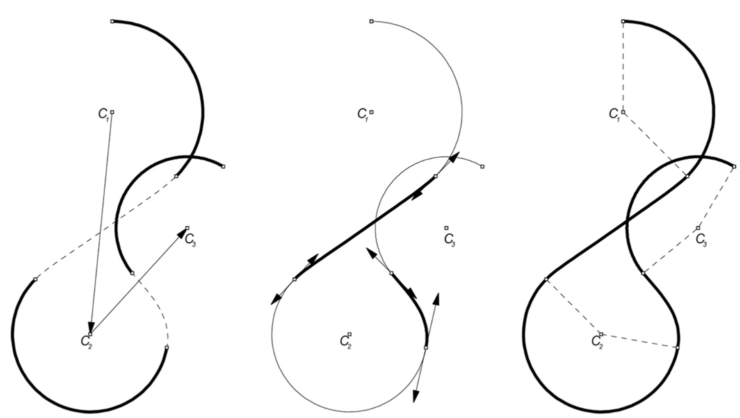

Figure 7: *(Left); Order of the arcs. (Middle and Right); Blending the arcs with G^2 continuity to create one piece of the path.*

Adding Rumi Motifs

The two main components of a plain rumî shape are the semi-circular part called a pivotal ball or almond [7], and the curve that joins the naked edge of the almond to the path with G^2 continuity (Figure 8). The placement of the rumî motifs can be generalized by reparameterizing the piece of the path and defining two parametric points t_1 and t'_1. The almond is drawn by an arc along the vector v_1. This vector is the perpendicular direction to the path at t_1. Positive and negative multiplications of this vector cause the motif to be flipped on either side of the path. The length of this vector determines the size of the almond.

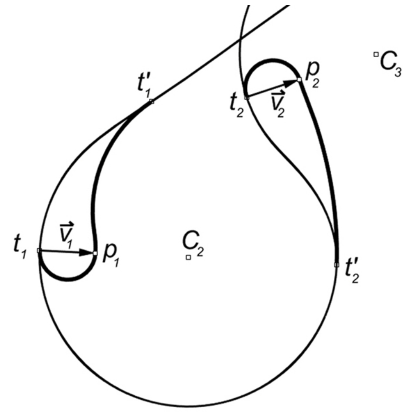

Figure 8: *The semi-circular almond shape and blending operations, creating the plain rumî.*

Rotational Symmetry

After finishing a single piece of the path with rumîs on it, the continuous path is constructed by a rotational symmetry operation. This operation usually uses 5, 6 or 8 copies of the branch rotated around the origin. However, in the continuous rumî style, there is a special condition for the placement of arcs. The first and last arcs should have a geometric continuity of curvature to make the whole path a single connected curve without gaps. In most cases, this can be accomplished by simply splitting a single arc into two, making one piece the first arc, and the other piece the last arc of the order.

Testing the Algorithm

The basic geometric definition described above can be applied to most continuous rumî compositions. It can be established by using basic drawing commands of most CAD software. We approximated some of the classical rumî compositions by using above algorithm. Figure 9 shows an example drawing and its re-construction using the algorithm.

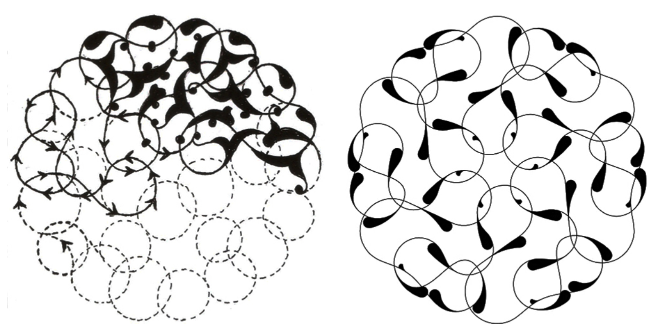

Figure 9: *(Left); Drawing of "Sürgit", a continuous rumî composition found at Topkapı Palace Museum Archives Nr. H2153-90a from* [5]*; (Right); Our first re-construction. Notice the similarities of the paths and differences between the rumî motifs.*

First tests reveal that in general, the algorithm is re-constructing rumî paths successfully. But it also tells that there is more study needed to perfect the algorithm, and create more detailed and accurate results. Especially the placement, orientation and the detailing of rumî motifs should be further studied. More sophisticated motif types -other than the plain rumî- should be studied. This test and the mathematical definition behind it led us to think about a design tool that generates rumî-like compositions. The final phase of this study includes the preliminary results of this tool.

The Parametric Design Tool

Grasshopper plugin for Rhino is a suitable interface to create data-flow diagrams, which enables fast and efficient algorithms of parametric curves and surfaces to be developed by non-programmers. The analysis and construction steps explained above are used to understand the basic geometric structure of rumî compositions. However, Grasshopper interface presents some ready-made geometric solutions for operations like placing points, drawing arcs and blending curves. This is why there are additional components in the design tool presented at this stage (Figure 10). For example, the parameter inputs are controlled by graph mappers instead of direct numerical inputs, which enable faster and more efficient control over the inputs while generating variations. In addition, the arcs are drawn by using polar coordinates and angle domain inputs instead of the parametric functions described earlier. These modifications made it easier for a non-programmer designer to generate and study rumî compositions.

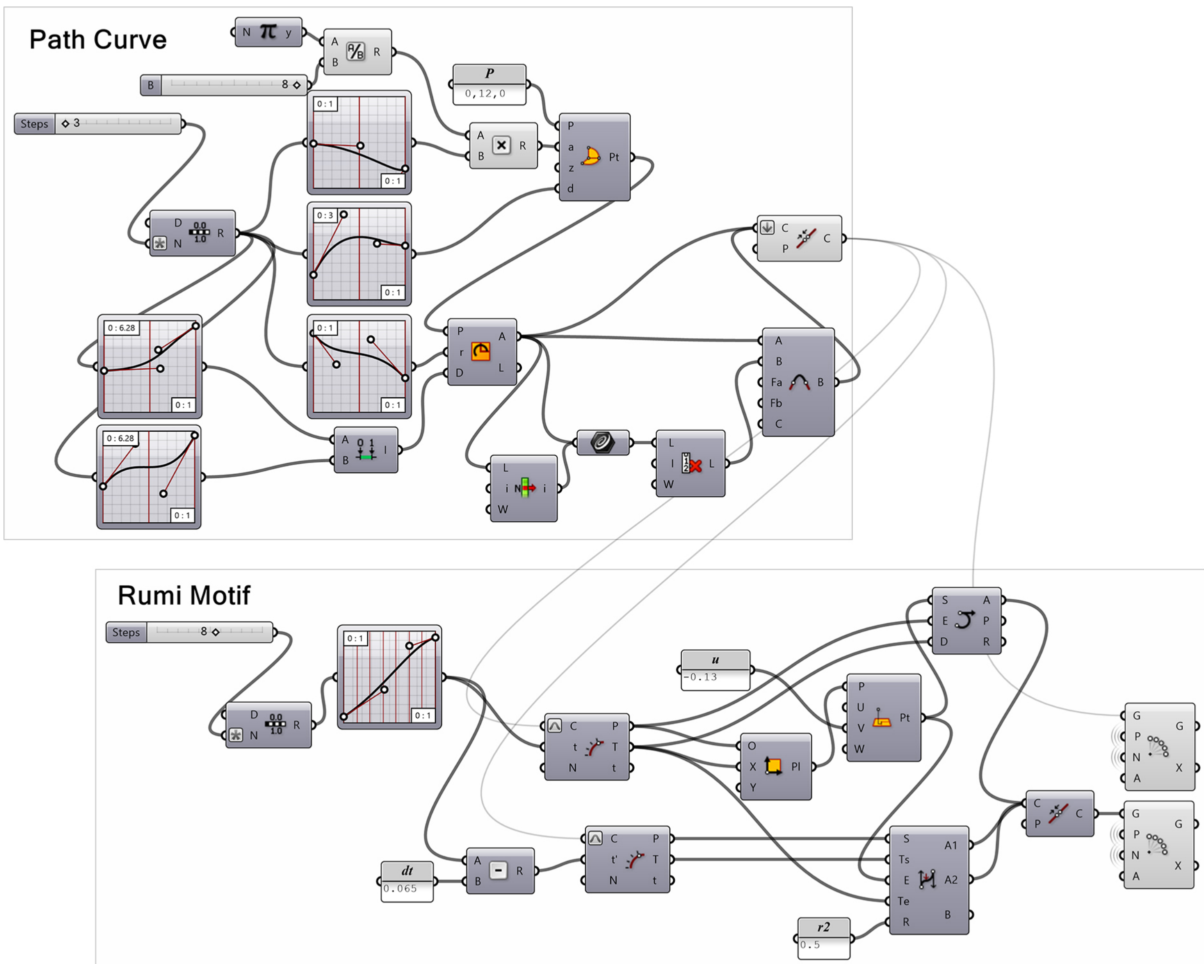

Figure 10: *The rumî design tool developed with Grasshopper for Rhino.*

We designed new instances of continuous rumî compositions by using the algorithm and tool explained in this paper. Below are some of the preliminary results we've created while playing with the parameters (Figure 11). Notice that these designs are based on the same geometric principles with classical rumî compositions but they are also capable of being very different from them. The Grasshopper definition can be downloaded at www.designcoding.net.

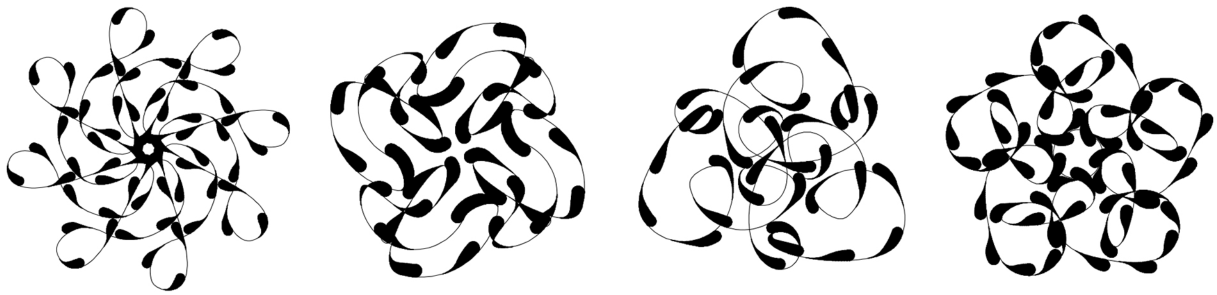

Figure 11: *New designs generated by the algorithm. It is also possible to create animated generations.*

Conclusions

The classical examples and the new variations generated by our algorithm show that the proposed algorithm is working at least partially properly, both in terms of analyzing and digitizing a classical art, but also designing and creating new instances. However, there are still many topics that could be further studied. The tool and the algorithm explained in this paper could be further improved by including more motif details, other path types other than continuous, and other boundary types other than circular.

It may not be necessary to convert every traditional art style as the content of generative art. But in this special case, digital technologies are utilized to re-introduce an art style with a motivation that this would be a small step in its long historical development. In fact, most of the classical styles of Seljuk and Ottoman decorative arts and motifs are still waiting to be studied in this way. We believe that the digital era is another step for the transformation of rumî, just like the transformation happened in the Islamic era, with new attitudes, beliefs and ways of expression. Parametric modeling and the underlying mathematics become a new language to re-unite different cultures around the world. We hope that more studies on similar cultures would enlight our mutual past and future. Today, parametric designers and mathematicians are taking the role of shamans, pioneering, and giving meaning to endless combinations, generated from a single algorithm.

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