

# Non-linear volumetric music composition in a VR context: project “Omega”

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## ABSTRACT

Technological progress in development of XR creative spaces influences our perception of the piece of art. The use of gestural control enables interaction with the spatially distributed elements and creates conditions, where the user participates in a co-creation of a virtual experience. When applied to music art, the spatialization along with interactivity promotes non-linearity of musical structure, resulting in a new instance of music, out of the initial set of possibilities. In this article, we present a concept of a volumetric music composition, which maps music form to a 3D VR space, with a possibility of a variance at each mapping point. We implement a concept in a volumetric VR music composition “Omega”, which allows the user to choose between two alternative paths at each stage of the form development. The user’s action affects not only the changes in music, but triggers the colorization of the surrounding space, color being the reflection of the chosen musical path. Along with the music form spatialization and surroundings colorization, we integrate the paths of gestural movement, which user may choose to follow, adding visual aesthetics to the act of music creation. The synesthetic nature of the composition tightly binds music, color, 3D space and movement into one act of expression in a co-creation of a musical form. The article describes the context, philosophy and details of realisation of the concept’s practical implementation.

## 1. INTRODUCTION

The graphical musical form representation has a long history, starting in XIX century with Eric Satie, who was the first to create a music content, which graphically represented shapes of a non-musical form in a two-dimensional space. The use of an additional dimension started with the geometric transcription of Bach’s music compositions done by Yannis Xenakis, followed by the appearance of three- and four- dimensional representations of harmonic structure in the XXI century [1, 2]. The technical possibilities brought with the virtual reality (VR) headsets, allowed distributed 3D compositional representation of painting, being experienced in a VR space [3, 4]. The combination of a distributed 3D compositional representation

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along with the graphical musical form evolution, leads us to the creation of a volumetric non-linear interactive music composition, experienced and co-created in a VR space.

The rising interest to the volumography in music videos production has been mentioned in scientific literature [5, 6], which reports the audience expectation of interactivity with the 3D objects [6]. The same direction follows the definition of Musical XR, which is characterized by the conditions, in which musical elements are controlled through manipulations of their properties, such as pitch, timbre or dynamics [7]. We propose the music architectural manipulation through stages of the form development, mapped to a visual representation of 3D objects in a VR space, which extends the current state of the art. The interaction with these elements with a haptic feedback (vibration of the hand triggers) and implication of the proprioceptive function through different positions of the mapping points (low and high), engage all sensory modalities currently offered in VR systems.

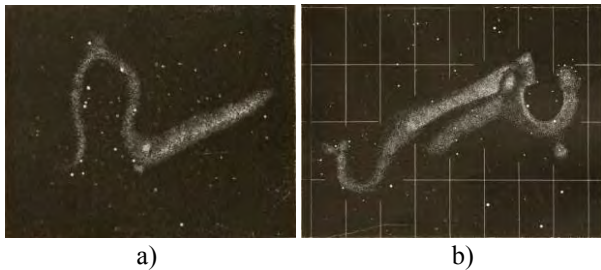
The nonlinearity of music composition appeared in the XX century and was closely related to the interactivity, since it gave the score performer a possibility to choose music events to follow during the performance. The non-linearity of music form implicitly inherent to the postmodern music is rather seen as a non-centered music matter development, achieved by a small variation of gradually added rhythm-melodic elements, as in minimal music by Steve Reich, or in a gradual addition of intervallic structures embraced by strophic forms, inherent to compositions by Arvo Pärt [8]. The absence of movement towards culmination results in a musical form-being with non-hierarchical local micro-development, which correlates with the non-hierarchical structure of rhizome introduced by a postmodern philosopher Gilles Deleuze [9]. In our project, both interpretations of non-linearity are employed, giving the user a choice of music events to follow, which are embraced in a strophic form with a static non-centered development. Thus, the project “Omega” embodies postmodern form-being in an interactive way through a new medium.

Given the above, we define of the concept “volumetric composition” as a piece of music, the constructive elements of which are distributed in a 3D space – either physical or virtual, allowing the user to interact with each of these elements in a linear or non-linear manner. The volumetric music composition should be distinguished from VR sound navigation systems [10, 11] where sound sources visualized in a form of 3D objects bare no initial composer intention.

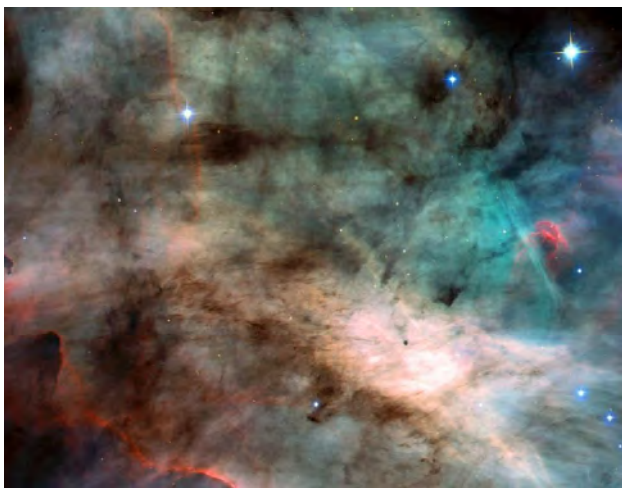
## 2. VISUAL STRUCTURE MAPPING

The inspiration of the compositional structure shape in a 3D space comes from a stellar composition of the Messier 17 nebula, also referred as Swan Nebula or Omega Nebula, following John Herschel's drawing made in 1833 and 1837 respectively (shown in Figure 1). The points representing important music form development stages were placed in two parallel rows, following visual configuration of the reversed shape of the 1833 drawing [12], with reasonable modifications, to match the dual choice principle of the music composition. Thus, each of the parallel rows receives its proper name and color palette, which will be used for surrounding space colorization. The drawing of the nebula gives a clear path for points placements, while the scientific colorization of the image of the nebula made by Hubble (see Figure 2) inspired a color palette, summarized to a combination of blue and red spectra.

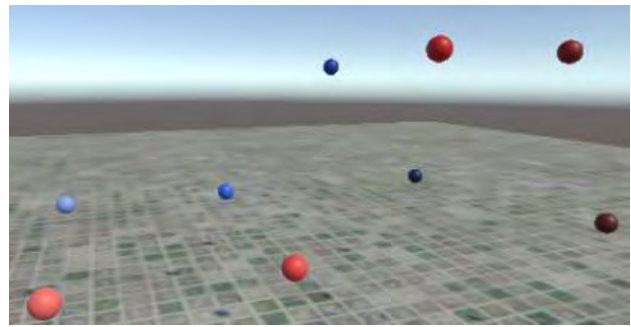
The Swan path is represented with the shades of a blue color and the Omega path uses the shades of red. The intensity of the color shade corresponds to the events ordering, where lighter shades are used in the beginning of the piece and the color intensity increase reflects the stages of the music matter development. The VR mapping of both paths is presented in Figure 3.



**Figure 1.** John Herschel's drawings of Messier 17 nebula a) the drawing made in 1833 and referred by Herschel as "Swan Nebula"; b) the drawing from 1837 and referred as "Omega Nebula". Pictures adapted from [12].



**Figure 2.** Hubble image of Messier 17 nebula. Pictures adapted from [13].



**Figure 3.** VR structure mapping in two parallel paths – Swan path (in the shades of blue) and Omega path (in the shades of red).

The media materials of the current project are available online [14].

## 3. COMPOSITION PHILOSOPHY

The semantics of chosen colors reflects the compositional philosophy, expressing a duality of existence through the opposite beginnings: utopian transcendence, metaphorically related to the image of a beautiful celestial bird swan, and dystopian fatality, related to the omega symbol - the last letter of a Greek alphabet, commonly associated with apocalyptic meanings.

The duality of existence is realized not only by visual means – the change of a fundamental tone, axed to the common tone of a third, expresses the same idea by means of music matter development. The change of the fundamental represents the main harmonic signature for both pieces, which makes possible the mutual exchange of the music form development stages.

The similar change of the fundamental, axed to the common tone of a third, was used by John Tavener in his *Funereral Canticle* to express the transcendence from the terrestrial world, embodied in a duo, performing a religious routine melody in F-dur, to the celestial world, with the choir singing much complex music matter, in terms of harmonic organization, marked by the tonality shift to fis-moll – a tonality of the common third with F-dur. The use of natural dominants and seventh chords in a choral part, along with a perpetual micro change of harmonic patterns, creates non-centered music matter development, perceived as endless, eternal state [15]. Similar to John Tavener's composition, a constant change of harmonic patterns, embraced by the common harmonic signature, allows creating form-state perception of both pieces.

## 4. MUSIC STRUCTURE

The harmonic language of the project is complex and although the pieces contain triadic structures, there is no central tonality to be defined. The music matter follows a multi-center tonal organization, when instead of one tonality, a cluster of tonalities appears and the relation between two neighboring chords defines the tonal center at a given point of time. The multi-center tonal organization may be considered as a natural path of harmonic development after late romanticism with Wagnerian enharmonic and elliptic

chains and tonality dissemination, which was pushed to the limits with atonal theory. However, since postmodernism seeks to restore the constructive elements of the past within a new context [16], a cluster of tonalities with preserved triadic structures seems to be a viable alternative to the tonality annihilation.

The structure of both pieces heavily relies on harmonic development. Both pieces are starting with the interval of a minor third, while the relation of primary tonalities fundamentals is of a major third (*c* for Swan and *e* for Omega). The minor-major duality of the third drives the development of both pieces in many configurations such as:

- 1) Intervallic succession of minor and major thirds in Omega path;
- 2) Major and minor third in the structure of the triad with the same fundamental, which adds dystopian dramatism in both paths;
- 3) Common third, which plays the role of either minor or major third, depending on a changing fundamental – a harmonic equivalence pattern of both pieces, which expresses the exaltation of the universal beauty with the unescapable finality of existence.

The form of each piece may be defined as a strophic form with variations and can be represented alphabetically as follows:

$$\text{Swan: } A - A^1 - A^2 B - A^3$$

$$\text{Omega: } A - A^1 - A^2 B - A^3 B^1 - A^4$$

The primary tonality of each strophe reacts to the introduction of a *B* element by a semi-tone descent:

$$\text{Swan: } c - c - h - c$$

$$\text{Omega: } e - e - es - es - e$$

This tonal structure resemblance creates another level of connection between two pieces. Let's now analyze the harmonic development of each piece separately.

*Swan*. The primary tonality, which creates a global structure, is followed by multiple changes within the cluster of tonalities for a given strophe and the relation between two neighboring tonalities may be expressed alphabetically using the following alphabetical designation and a color scheme:

1. **A**: minor tonic – Dorian minor VI relation (ex.: c-moll – a-moll);
2. **B**: natural dominant – minor tonic relation (ex.: a-moll – d-moll);
3. **C**: chords with a common third (ex.: d-moll – Des-dur);
4. **D**: chords with a common fundamental (ex.: c-moll – C-dur);
5. **E**: minor tonic – double dominant relation (ex.: c-moll – D-dur);
6. **F**: minor tonic – minor VI relation (ex.: e-moll – c-moll);
7. **G**: major tonic – flat major III relation (ex.: C-dur – Es-dur);

8. **H**: minor tonic – Neapolitan minor II relation (ex.: c-moll – cis-moll);
9. **I**: parallel tonalities (ex.: C-dur – a-moll).

The colors chosen to mark the chord relations describe a degree of a major's "heat": the relations between two minor triads are marked by a cold palette of blue and green with their combination (**A, B, F, H**), while the presence of major triads adds red shades to the palette (**C, D, E, G, I**). The color allows to create a correspondence between two pieces, while alphabetical representation reflects the order of the relation appearance in a specific piece. Using this relations scheme, let us build the harmonic structure for the Swan piece:

$$\begin{aligned} 1^{\text{st}} \text{ strophe: } & \quad A - B - C - C \\ 2^{\text{nd}} \text{ strophe: } & \quad D - C - E - D - F - C - C - C \\ 3^{\text{rd}} \text{ strophe: } & \quad D - C - D - G - C - C - D - H - C - D \\ 4^{\text{th}} \text{ strophe: } & \quad A - B - C - I - F - B \end{aligned}$$

The hybrid visualization of the harmonic development inherent to the Swan piece reveals the logic of the new harmonic relations addition. After the exposition of the three first relations in the 1<sup>st</sup> strophe (**A, B, C**), which creates the arch with the 4<sup>th</sup> strophe, new relations are introduced via alternation with the main harmonic signature (**C**) at first in a singular mode (**D, E**) in the 2<sup>nd</sup> strophe; then, being coupled with the common fundamental relation (**D**) in a middle of the 2<sup>nd</sup> strophe (**D - F**) and the 3<sup>rd</sup> strophe (**D - G, D - H**). We can see that the common fundamental relation (**D**) expands starting from its appearance in the 2<sup>nd</sup> strophe, invading the harmonic space of the 3<sup>rd</sup> strophe. The harmonic development of the 3<sup>rd</sup> strophe is structurally close to the harmonious concentric circles form (**D - C .. C - D**) with the main harmonic signature relation in the center (**C - C**), if new relations **G** and **H** are considered as variations of **D**, which precedes their appearance. Finally, the parallel tonalities relation (**I**) is introduced in the last 4<sup>th</sup> strophe.

We also may observe the increase of the harmonic intensity through a passage from a Dorian minor VI (**A**) and natural dominant (**B**) relations to the less related chords with a common third (**C**) already in the 1<sup>st</sup> strophe. The 2<sup>nd</sup> strophe, along with close double dominant relation (**E**) and less close relation of chords with a common fundamental (**D**), contains very distant intense harmonic relation of the minor VI (**F**). In the 3<sup>rd</sup> strophe, the harmonic intensity increases with the flat major III relation appearance (**G**): the only major-major relation of the piece, which is further neutralised by a minor tonic – Neapolitan minor II relation (**H**). Finally, the 4<sup>th</sup> strophe brings the harmonic intensity discharge with very close parallel tonalities (**I**) and natural dominant (**B**) relations. A certain level of intensity remains with the Dorian minor VI (**A**), chords with a common third (**C**) and minor VI (**F**) relations to finish the piece.

Exploiting the same color scheme, let's visualize the list of tonalities, which appeared within described relations:

$$\begin{aligned} 1^{\text{st}}\text{s.: } & \quad c-a|a-d|d-Des|Des-d \\ 2^{\text{nd}}\text{s.: } & \quad c-C|C-cis|des-Es|Es-es|dis-h|h-B|B-h|h-B \end{aligned}$$

3<sup>rd</sup>s.: *h-H|Ces-c|c-C|C-Es|Es-e|e-Es|Es-es|es-e|e-Es|Es-es*  
 4<sup>th</sup>s.: *c-a|a-d|d-Des|Des-b|b-d|d-a*

The migration of the tonalities within common third relation (**C**) reveals minor second movements in downward (*d-cis*) and upward (*h-c*) directions, being in the range of the ancient *passus duriusculus* melodic pattern, which expresses intense dramatism. The migration is finished by a major second downwards movement (*e-d*), returning to the initial point (*d*), which correlates with the existential finality. The common fundamental relation (**D**), which augments its presence in the 2<sup>nd</sup> and 3<sup>rd</sup> strophes, also tends to expand its region of tonalities coverage (*c-es-h-c-es*). The Dorian minor VI (**A**) and natural dominant (**B**) relations remain tightly bound to their tonalities (*c-a, a-d, d-a*), adding stability to the constantly changing harmonic patterns.

Along with the tonal relations, the means of harmonic expression comprise the structure of chords with additional tones and their alterations. Thus, a sharp fourth regularly appears within the common third relation on a feeble time, adding to the melodic development, which is mostly drawn by a harmonic flow. Major seventh within a minor seventh chord augments a dramatic effect of existential finality, while major/minor third inside the same chord structure expresses the duality of existence.

*Omega.* Let's define an alphabetical order of the relations appearance in the Omega piece, using a common color palette with the colors choice logic described earlier:

1. **A**: chords with a common fundamental (ex.: c-moll – C-dur);
2. **B**: parallel tonalities (ex.: C-dur – a-moll).
3. **C**: tritone relation between 2 minor triads (ex.: fis-moll – c-moll);
4. **D**: chords with a common third (ex.: d-moll – Des-dur);
5. **E**: minor tonic – Dorian major VI relation (ex.: es-moll – C-dur);
6. **F**: tritone relation between major and minor triads (ex.: Fis-moll – c-moll);
7. **G**: minor tonic – minor VI relation (ex.: e-moll – c-moll);
8. **H**: minor second relation between two minor chords (ex.: cis-moll – c-moll);
9. **I**: major tonic – flat VI minor relation (ex.: C-dur – as-moll);
10. **J**: major tonic – flat VI major relation (ex.: C-dur – As-dur).
11. **K**: minor tonic – Dorian minor VI relation (ex.: c-moll – a-moll).

Let's build the harmonic scheme of Omega piece development using described formalism:

1<sup>st</sup> strophe: *A – A – B – C – D*  
 2<sup>nd</sup> strophe: *A – A – E – A – F – D – B – D – A – G*  
 3<sup>rd</sup> strophe: *A – A – B – H – A – I – D – D – D*  
 4<sup>th</sup> strophe: *A – A – E – A – J – I – K – D – D – D*  
 5<sup>th</sup> strophe: *A – A – A – H*

The common fundamental relation (**A**) stabilizes the dynamism of the relations change, returning at the beginning of each strophe. It also tends to precede the introduction of a new relation: **A – B** in the 1<sup>st</sup> strophe, **A – E** along with **A – F** and **A – G** in the 2<sup>nd</sup> strophe, **A – I** in the 3<sup>rd</sup> strophe, and **A – J** in the 4<sup>th</sup> strophe. Very distant relations of minor triads – of a tritone (**C**) and of a minor second (**H**), are preceded by a close relation of parallel tonalities (**B**) in the 1<sup>st</sup> and the 3<sup>rd</sup> strophes respectively, creating relaxation of a harmonic density just before its immediate concentration. The common third relation (**D**) gradually increases its presence through the piece, being replaced by a very distant and harmonically dense minor second relation (**H**) in the last 5<sup>th</sup> strophe. It is quite remarkable that the last new relation introduced in the Omega piece (**K**) is the very first relation that appeared in the Swan piece; it is also appears close to the golden ratio zone. This event is preceded by the only major-major relation of the Omega piece (**J**), representing a flat major relation, similar to the flat major relation – also a unique major-major relation in the harmonic structure of the Swan piece. The difference lies in the third's direction – the Swan piece contains an upward flat relation (flat major III), while Omega contains a downward flat relation (flat major VI), related to a major tonic. This creates a complementary relation between two pieces, as a reflection of the utopian (upwards) and dystopian (downwards) beginnings.

Let's now visualize the list of tonalities, which appeared in the Omega piece within described relations:

1<sup>st</sup>s.: *e-E|e-E|E-cis|cis-g|g-Ges*  
 2<sup>nd</sup>s.: *e-E|e-E|E-g|g-G|G-cis|cis-C|C-e|e-Es|Es-es|es-g|*  
 3<sup>rd</sup>s.: *es-Es|es-Es|Es-g|g-ges|ges-Ges|Fis-d|d-Des|Des-d|d-Des|*  
 4<sup>th</sup>s.: *es-Es|es-Es|Es-ges|ges-Ges|Ges-D|D-b|b-cis|cis-C|C-cis|cis-C|*  
 5<sup>th</sup>s.: *e-E|e-E|E-e|e-es|*

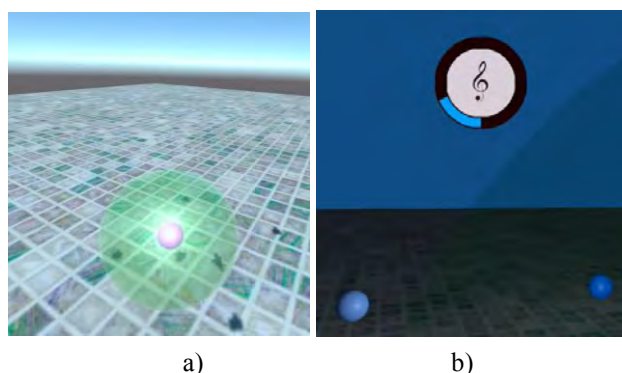
The tonalities movement within the common third relation is started with a downward jump to a tritone (*g-cis*), then upward pass to a minor third (*cis-e*) and gradual descent to the tritone's base tone (*e-d-cis*). The tonalities movement within this relation is much more dramatic, than in the Swan piece, where the movements on small intervals within a range of a perfect fourth (*h-e*) took place. A dissonant tritone interval, suddenly taken by a downward movement, the attempt to raise on the interval of a minor third and a fatal descent to the tritone jump's hole creates dystopian associations. The tonalities coverage within the chords with a common fundamental is similar to the tonalities movement within the same relation in the Swan piece and do not surpass the interval of a major third (*e-g-ges-es-ges-e*). However, instead of raising above the starting tonality, the tonal movement in the Omega piece returns to its initial point.

The means of harmonic expression in the Omega piece also comprise the use of additional chord tones with alterations. The sharp fourth along with the major/minor third within the same chord structure are also used in the Omega piece to express the similar meaning as in the Swan piece. Unlike the Swan piece, the alternation of the minor and major seventh within the major seventh chord is used to

add harmonic density and the dynamism of a dominant sounding. It is also should be noted, that either resolved directly or via ellipsis dominants add dramatism and instability to the whole piece, compared to a more static Swan piece. Finally, the relation of stability within two pieces is supported by a rhythmic organization. The same metric structure was used for both pieces with twice more agitation in Omega (100 bpm) compared to Swan (50 bpm).

## 5. INTERACTION AND GESTURAL CONTROL

The interactive aspect in the context of the processual art requires a clear indication of the elements that may be triggered at a given moment of time. In our project we wrap the potential points to trigger inside semi-transparent spheres, which gradually shrink until the exact moment of interaction, requesting the user to decide which audio event will be activated (see Figure 4). Since the sphere is bound to the point and it might go offset the user's field of view, we integrate an additional indicator synchronized with the sphere movement, which stays in the user's field of view at all times. This solution not only helps to maintain the order of interaction, but also guaranties the continuity of performance and integrity of the music piece.



**Figure 4.** Semi-transparent spheres, indicating the next element to trigger (a); an additional indicator of the timing (b).

The surrounding space elements colorization is affected by the sound events choice and the surrounding canvas is gradually colored in shades of colors inherent to the chosen points. The surrounding canvas is divided into regions and each region may be equally affected either by Swan path's color palette or by the color palette of the Omega path. An example is given in Figure 5.

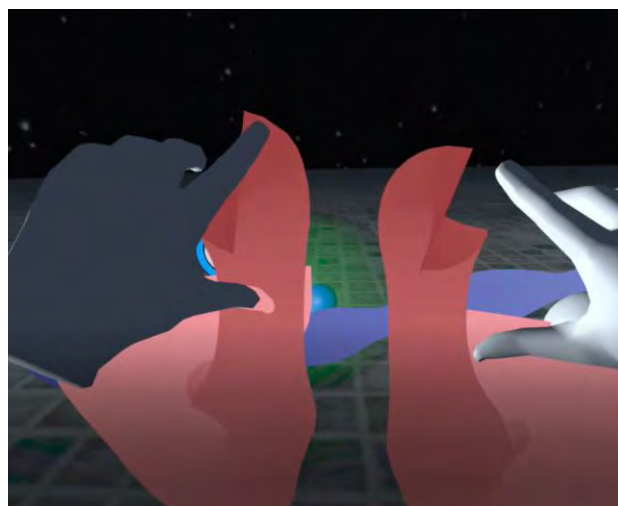
The gestural control makes an integral part of the user's experience and is implemented via gestural movement paths. The movement paths are represented as semi-transparent traces of the dancer's hand movements, recorded from touch controller's coordinates during the dancer performance in a VR space. The dancer's guiding movement paths are unrolled in time, engaging the user to follow. The user's hand movements are leaving their own traces, which allows to assess how close the user movement was to the guiding dancer's movement. To prevent the saturation of lines, both guiding and the user's hand traces begin to fade just after their appearance. Since gestural movements are

tightly bound to the points being triggered, we provide 5 pre-recorded combinations of interaction possibilities with both paths, an example of such variability is given in Figure 6. There is also a possibility to turn off the pre-recorded movements, leaving the user a complete freedom in a piece stages combination and gestural movements.



**Figure 5.** Canvas regions after interaction with one Swan element (shades of blue) and two Omega elements (shades of red).

The choreography of the guiding movements represents modern dance style, including *chaine tour* (chain turns), *glissade* (gliding steps) that predicate *jetes* (jumps) or *tour de basque* (leaps), along with front-to-back and side-to-side steps. The dance choreography is interpretative and conveys the main artistic message, related to the compositional philosophy, expressing the fragility of human existence and the eternal beauty of the universe – the duality of physical and metaphysical presence, embodied in a transcendent artistic experience.



**Figure 6.** Guiding traces interacting with the Omega and Swan points.

## 6. CONCLUSIONS

The article presented a concept of a volumetric music composition along with its practical implementation in a VR application. The compositional philosophy and its realization in a music matter has been shown via hybrid visualization and detailed analysis of harmonic relations and tonal movements. The principles of the interactive points with the related surrounding regions colorization were shown and the models of interaction with the project's visual interface via guiding traces have been discussed. The project presents a great potential for co-creation hybrid VR experiences of a music art.

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