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Study 7/0: Error-Generated Spatiotemporal Animation

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Abstract

Study 7/0 explores the positioning errors of a static GPS receiver in a series of generative procedures. It is motivated by the idea of cognitive mapping as a configuration of individual, non-linear and discontinuous spatiotemporal experiences, and their outcomes. We use technical flaws as a conceptual source material for further creative processing and expression. With *Study 7/0*, we also investigate the effective approaches to emergence in generative art, where a simple initial setup of a complex system can produce surprising phenomena. In this paper we focus on the initial animation based on the 2D waypoint data (longitude and latitude) and the timestamps recorded in the GPS Track Log path. Project web page: http://dejangrba.org/art-projects/en/2018-study-7-0/index.html.

Keywords: Animation, Cognitive Mapping, Data Visualization, Data Sonification, Error, Generative Art, Geometry, GPS, Inaccuracy, Visualization, VR.

1. Concept

Study 7/0 explores the positioning errors of a static GPS receiver in a series of media transcoding procedures. It is motivated by the idea of cognitive mapping as a configuration of individual, non-linear and discontinuous spatiotemporal experiences, and their outcomes. As a wayfinding framework, the GPS facilitates a layered set of interactions. observations, preferences, choices, decisions and compromises that constitute the contemporary way of life. Since the useful GPS routes are always defined by accessibility and environmental constraints such as geography, traffic, consumption and communication flows, the errors of that system point to the quirky and idiosyncratic misalignment between the subjective identity and the functional requirements of human infrastructures. In a broader symbolic sense, the individual navigation through and the adaptive correction of the systemic imperfections of complex infrastructures such as the GPS point to the notion that politics, before it becomes public, is always personal, intimate matter [1].

While the majority of new media artworks since 1998 have relied on the accuracy and reliability of the GPS for various forms of mapping, tracing and transcoding [2], in *Study 7/0* we focus on the imperfection as a logical counterpart and a criterion of the utility of the GPS or any other technical system. We use technical flaws as a conceptual source material for further generative processing and expression, unlike the conventional glitch art in which the error is an aestheticized frontline layer [3]. In a series of stages of this project, we also investigate the effective approaches to emergence in generative art, where a simple initial setup of a complex system can produce surprising phenomena [4,5].

2. The Initial Procedure

2.1 Generating the GPS Dataset

We secured a Garmin GPSmap 60Cx GPS receiver to a desk, powered it from the outlet, selected the Track Log function, and let it run for 7 days, 7 hours, 16 minutes and 11 seconds (from 7 July 2010 04:46:36PM to 15 July 00:02:47AM). Garmin GPSmap 60Cx is a handheld GPS navigation device, well regarded for its high sensitivity, accuracy, functionality, ruggedness and reliability. Track Log function starts as soon as the receiver gets a satellite location fix, and saves the time, location, elevation, distance and speed data about the waypoints which are automatically created according to the selected sampling method: time, distance or frequency.

For an immovable GPS receiver, the ideal Track Log is either a series of overlapping waypoints with the identical location and elevation, zero distance and speed plus a number of timestamps if the selected sampling method was time or frequency, or it is a single waypoint (location and elevation), with zero distance and speed plus a single timestamp if the selected sampling method was distance. However, our setup had recorded a Track Log of 8438 positions on a 34.7km long path covering an area of 2.1km^2, with an average speed of 0.2km/h and a maximum speed of 17.9km/h (Figures 1 and 2). This is a consequence of the limited precision of a GPS receiver operating inside a building under slightly changing weather, combined with the inaccuracy of GPS infrastructure [6].

Figure 1. Horizontal projection of the Track Log path in MapSource software.

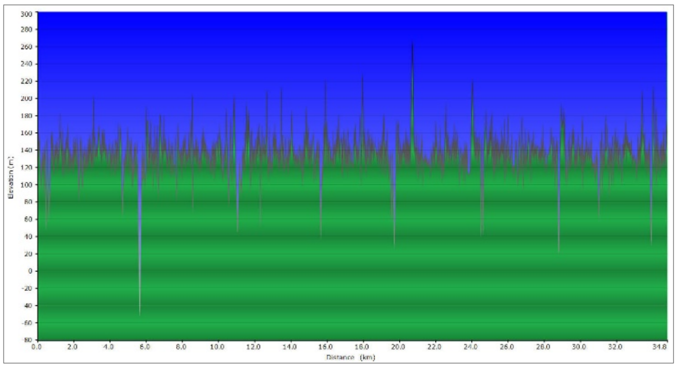

Figure 2. Elevation data of the Track Log path in MapSource software.

We have originally produced this dataset in the *Study* project (2010) for the *Rhizome of the City* exhibition in the Museum of Science and Technology in Belgrade, which explored the artists' cognitive mapping through GPS and the Internet. We combined the Track Log path (longitude, latitude and altitude) (Figure 3) with the geopaths of the IP routes for the websites we had been browsing while the GPS receiver was running the Track Log [7].

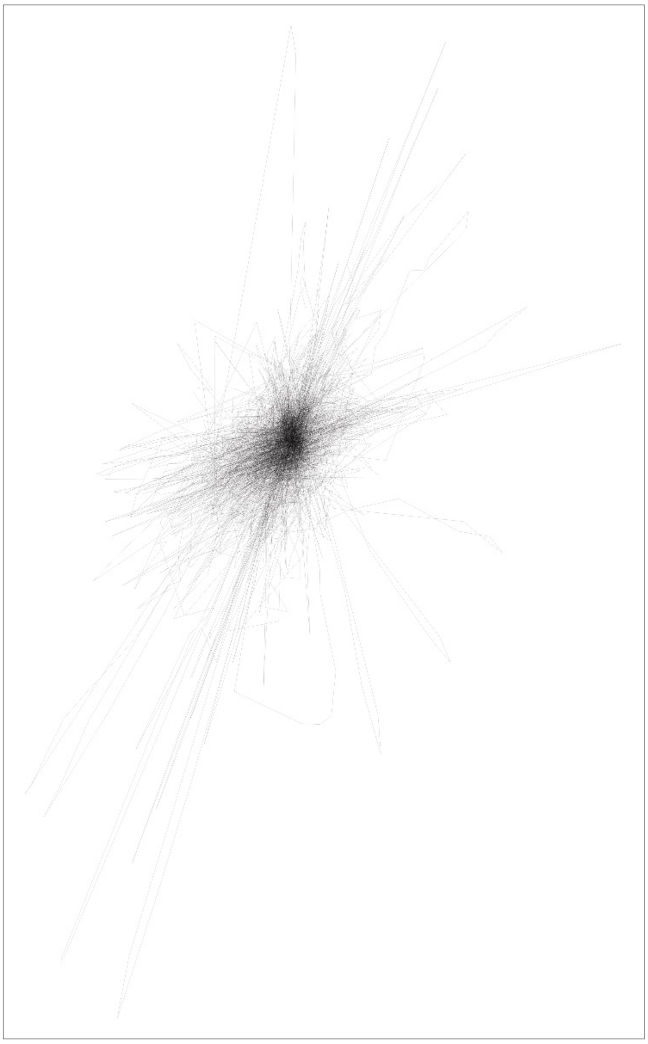

Figure 3. High resolution horizontal projection of the Track Log path.

2.2 2D Animation

The recorded Track Log is a complete spatiotemporal dataset consisting of spatial coordinates (longitude, latitude and altitude) and timestamps. When interpreted in its original sense—3D points interpolated over time—it implies movement. To make the 2D animation in *Study 7/0* we used the timestamps of the 2D waypoint data (longitude and latitude) to move a red dot along the horizontal projection of the Track Log path, speeding up the 630,971 seconds of the real-time record into 4 minutes and 41 seconds (281.233 seconds at 30fps).

We created two versions of the animation. In the first, we isolate the current 2.25% (780m) section of the whole path, revealing the intricate dynamics of error-generated virtual motion. In the second, we follow the current 2.25% building up the whole path. To contextualize the visuals, we display all the values from the dataset: longitude, latitude, altitude, distance, hop (time between the two waypoints), speed and heading at the bottom, and the recording date, time, duration and path length at the top of the frame. The animations are resolution independent, and are usually presented either as synchronized two-channel HD videos in parallel, or precomposed in parallel as a single channel UHD video (Figures 4 and 5).

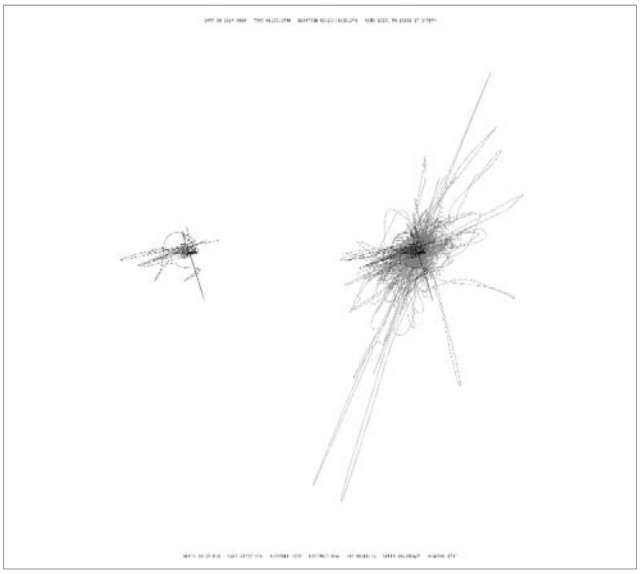

Figure 4. Frame from the parallel animation.

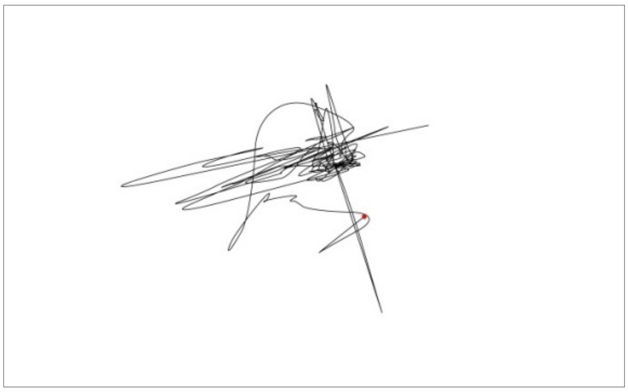

Figure 5. Detail of Figure 4 in UHD resolution.

2.3 Sonification

We consistently used the Track Log dataset as a generator for the sound material. An apparent way to turn such a dataset into sound would be the projection of the recorded GPS coordinates into a Euclidean space whose axes represent sound synthesis parameters such as, for instance, the frequency of an oscillator. However, we decided to follow the metaphor of movement in real space and to exploit the acoustic effects that result from it.

When a sound source or the listener moves about in space the distance between them changes. This change of relative distance produces Doppler effects and modifications of the volume because of distance-related damping. The Doppler effect refers to the change of the wave frequency due to a change of distance. If the distance between the source and the listener decreases, each sound wave takes less time to reach the listener. Hence, the sound waves are condensed, which results in an increase of frequency and the perception of a higher pitch. Conversely, if the distance increases, the sound waves are more spread out, the frequency is lowered, and a lower pitch is perceived. The distance-related damping of sound levels has two causes: the overall sound volume drops with the increase of the distance between the sound source and the listener, and there is an additional attenuation of high frequencies due to the energy loss of sound as it propagates through air.

We aimed to create a strong, yet only metaphorical analogy to these acoustic phenomena associated with the moving sound sources. We used delay lines whose variable delay times lead to shifts of the perceived pitch (the Doppler effect). We used low pass filters whose variable cutoff frequency recreates the effect of air absorption. However, we did not intend to establish authenticity by building a proper physical model. All these devices were applied freely as individual sound design components and scaled according to aesthetic considerations. The Track Log dataset was searched for the maximum deviation of the recorded waypoint from the actual geospatial location of the GPS receiver. This maximum distance defined a square with the actual geospatial location of the GPS receiver as its center. Four virtual sound sources were placed in each corner of this square, and the waypoint position data was used to control the movement of a virtual microphone (Figure 6).

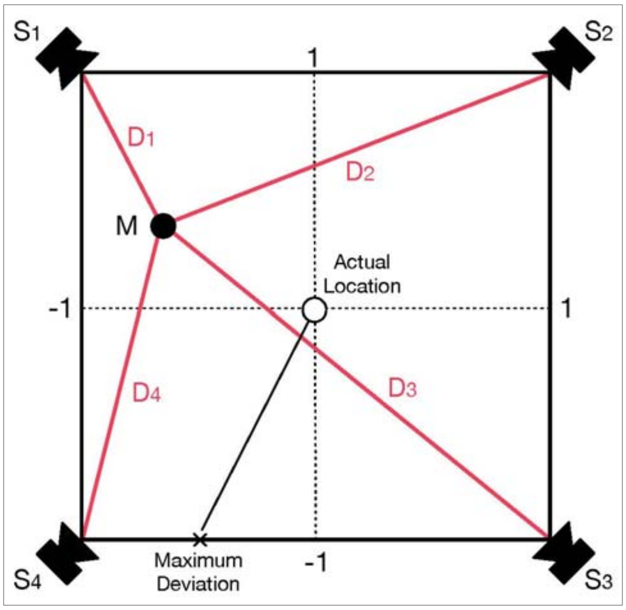

Figure 6. Four virtual sound sources (S1–S4) are placed in the corners of a square whose size is based on the maximum deviation. The waypoint position data control the position of the virtual microphone (M). The resulting distances (D1–D4) form the parameters for the sound processing.

In relation to the dimensions of the square, the coordinates of the microphone were normalized to the range [-1,1] and the distances between the microphone and the four virtual sound sources thus calculated. Subsequently, each signal was attenuated, filtered and delayed based on the respective distance (Figure 7).

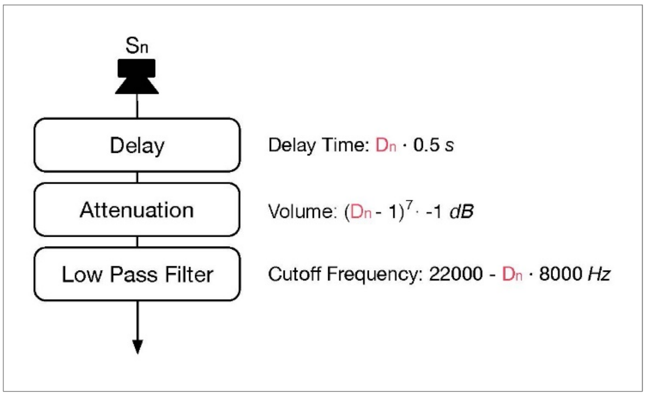

Figure 7. Signal flow for each of the four sound sources.

The sound material consists of band-limited pulse trains with the frequencies 3, 5, 7 and 11Hz. This superimposition of prime number frequencies yields a compact rhythmical texture. In the course of the piece, the four pulse trains become slightly faster, which creates a slow but steady increase in density. This compensates for the listeners' gradual habituation to the quality of the sound and is in line with the visual accumulation and increasing jaggedness of the animated path. The signals were further processed in order to enhance the sound. First, a high pass filter was applied to render the sound less booming. Second, the sound signals were distributed among the two channels, as if the virtual microphone was a stereo microphone. And third, a very discreet reverberation was added.

3. Further Development: Interactive VR Animation

The interrelated generative parameters recorded in the Track Log dataset allow different types of visualization, animation, sonification and presentation. We are developing an interactive animation using the three-dimensional spatial data (longitude, latitude and altitude) and the timestamps. This major iteration features an exploratory VR interface which initially puts the viewer in the subjective position of the erroneous GPS waypoint, and enables them to navigate the experience by changing the viewing angle, position and lighting parameters.

3.1 Structure

We will extrude a circle along the GPS path into a NURBS (Non-Uniform Rational Basis Spline) tunnel. Since the first and the last waypoint in the Track Log dataset have different relative positions (because neither the initial nor the final GPS waypoints matched the actual location of the GPS receiver), they will be joined so the tunnel will be closed to allow the looped animation.

3.2 Texturing and Lighting

The inner surface of the tunnel walls will be textured with a high reflexivity material (mirror), while retaining a certain degree of one-way transparency from the outside. The tunnel object will be illuminated from a rig of external light sources whose RGB color components are driven by the three spatial dimensions of the current viewpoint: back-front, left-right, down-up, within a range normalized to the extremes of the whole dataset. This texturing and lighting system applied to the serpentine tunnel structure which often intersects with other segments of itself will produce a rich and complex visual dynamic referring to the idea of an environment that challenges its own material reality [8].

3.3 Camera

The forward-looking point camera will be animated along the GPS path (central axis of the 3D tunnel) in a subjective point of view, following the speed and acceleration dynamics of the error-generated data. The tunnel-travelling subjective camera provides a logical and most effective although not the most descriptive/explanatory point of view. It was inspired by Peter Kogler's *Untitled (Ohne Titel)* (1993), and Gerhard Mantz's *Nirmala* (2013) [9,10].

3.4 Sonification

The sound synthesis algorithms will follow the metaphor of movement in real space, with the altitude as a specific acoustic parameter interacting with the chromatic values registered by the point camera.

3.5 VR Interface

The forward-looking camera angle will be a default, initially putting the viewer in the subjective position of the erroneous GPS waypoint. Ten seconds after each viewer enters the animation, the VR interface will allow them to navigate the experience. They will be able to reverse the viewing angle from looking forward to looking backward, change the angle arbitrarily, or step out of the tunnel and observe the red dot which will then represent the camera traveling along the complex 3D structure. They will also be able to alter the color space parameters of the lighting rig from RGB to HSB or LAB directly affecting the visual character of the tunnel viewed from the inside, and the look of the tunnel structure viewed from the outside.

3.6 Tuning the Experience

All key formal parameters in this design—such as the animation cycle time (speed), the degree of reflexivity and the one-way external transparency of the tunnel material, lighting rig configuration and lighting types—will be tuned for the most effective VR experience by experimenting in the studio, and by testing with various viewers. The aim is to create the setting with the optimal degree of ambivalence between disorientation and kinesthetic stability/confidence.

3.7 Continuity and Presentation

This design emphasizes the perceptual (visual, sonic and kinesthetic) complexity emerging from the GPS imprecision, so the narrative progression is not essential, and it is not required in principle by the concept and technical premise of the project. Rather, a continuous immersive animation will establish a strong impression of travelling in a short period of time (between 3 and 7 seconds), and will allow the viewer to enjoy the experience according to their individual preferences.

The project will be configured for the gallery exhibition with several VR sets and their corresponding video projections.

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