

**VIRTUAL FIREWORKS SIMULATION AS A NEW TOOL FOR
PYROTECHNIC MANUFACTURING AND CHOREOGRAPHY**

Alberto Navarro
Infinity Visions Inc.
USA

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**Alberto Navarro
Infinity Visions Inc.
Bellevue, USA**

ABSTRACT

“Visual Show Director” is a computer software program intended for scripting and simulation of fireworks displays and pyrotechnic effects in real time. The software allows the user to capture and record time cues to create a script where the effects descriptions are inserted. It consists of a time dynamic database consisting of row records of cues expressed in Hours-Minutes-Seconds and Frames and effect descriptions that are displayed and highlighted at the corresponding music or sound score time. The effects can be visually displayed in Real Time animation over a two-dimensional or three-dimensional background in a viewing screen. The effects are designed and created in a visual particle animation environment that translate the user inputs into a native scripting language that is used and interpreted by the engine.

The background consists of a two-dimensional image or three-dimensional complex models with textures. It contains multiple positions inserted with the 3-D Position editor. These positions are stored in a native file format and used by the engine to set the starting XYZ coordinate points for the effects particle animations. A Pyro Player postproduction application is used to display the simulation with autonomy from the original scripting software. The software enables the user to transfer files with the time cues, switch addresses, pre fire time, and caliber to a memory in an external Computerized Firing panel.

The software was developed using C++ and Visual Basic programming languages while Microsoft DirectX and OpenGL were used for the relative rendering. The engine is based on a Particle System, where each particle has a full set of properties that allow the software manage it.

INTRODUCTION

History of Visual Representation

For centuries humans have been looking for methods of visualization to represent concepts, ideas, processes, objects, and other physical phenomena. Through the visual arts they started to represent human acts, nature, and the human itself. Painting offered a two-dimensional representation and sculptures a three-dimensional one. Dance, theater, music, then animated drawings and motion pictures offered a 4-dimensional representation that came with the introduction of a temporal sequence of events.

The Renaissance period started a process of complexity and remarkable freedom. The creation of models and comprehension of the three-dimensional representation, with the construction of study models as a tool for design and visual rehearsal gave the artist an opportunity to improve their creations.

In our times we are involved in a unique period of history where digital technology and computer systems allow the continuous development of techniques of visualization. They take us beyond the visible objects or phenomena, with mathematically created models, by showing us before unseen processes of physics, biology and engineering.

New Visualization Technology

Computer-aided design technology is improving constantly the quality, economy and the construction methods themselves. We see Computer Assisted design (CAD) and 3D real time simulation as a new tool for engineers, architects, biologists, chemists, physicists, artists and a broad range of designers.

Until now the Fireworks world has been using two-dimensional representation with pictorial techniques, such as drawing, watercolors, and recently computer photo editing programs. The most common evaluation method is still the direct experience of firing the pyrotechnic effects. This is always slow and costly, and until the introduction of video recorders, these representations were difficult to archive and analyze.

The current methods of programming of sequences of effects use word descriptions with no visual data available, and lack the spatial or temporary conditions of movement and interaction of colors and shapes.

The simulation technology adapted to the necessities of the Pyrotechnic Designer or Fireworks Manufacturer, is allowing us to join the rest of the scientific, industrial and artistic world. Using real time particle animation methods, we can now virtually represent the nature of the fireworks.

Visual Technology: Benefits for the Pyrotechnician and Manufacturer

For the Pyrotechnic Designer this includes movement, dynamics, colors, shapes, and sequence of events in a temporal structure or a choreographic work. This virtual representation allows us to contemplate, analyze and modify the scenes until the desired order and balance is achieved. It transforms the artists' conception through dialogue and options arising in the course of the work process.

For the Fireworks Manufacturer, virtually testing the effects assists in product manufacturing and design. Finding new ways of distributing the particles, creating new shapes, movements, colors and sequences, are possible without having to build a shell or fire it. The desired visual result is rehearsed in the computer until satisfactory. The manufacturing process and structure can also be designed along with the visual experimentation. Once the desired effect has been virtually constructed, it can then be tested live.

The computer program offers to the artist options such as rectifying errors, duplication, automatic generated time sequences, combination and recombination, continual feedback, reversibility and visual polysensory design of effects that can be selected from a palette of options.

The speed of using visualization as a rehearsal tool is a great factor of progress, demonstrated in all the fields of research, and is also valid for the Art and Technology of Fireworks.

Visual Technology and Fireworks as an Art Form and Educational Tool

Fireworks are pure movement of colored light interacting with gravity and space. They are seen more as particles of light than as moving objects. A distant bird can be seen as a mere dot moving in the sky but is perceived by the mind as an object. Real-time visualization of particle traces in virtual environments can aid in the exploration and analysis of complex three dimensional vector fields. For example, testing multi- position, multi-angle firing sites.

The potential of creating realistic simulations, practical enough to be applied to the development of ideas and experiments, is sufficiently met in the real-time fireworks particle animation system developed. With the treatment of the particle sequences in rendering programs, the reality and luminous conditions can be greatly improved. The pyrotechnic artist can create displays with precision and surrealism that are difficult to achieve with imagination or drawing techniques.

Such a support technology increases the visual experience and capacity of the designer. It is also a great educational tool for training, studying and learning. It allows the designer to show visual concepts and performances to others who may not have the abstract idea of what the composition is about. This also makes of it a medium to archive and communicate visual fireworks concepts. It is also a platform to interactively create with other artists in the same projects, allowing quick feedback and real time input for anyone participating in the process. It can provide sufficient information to demonstrate safety distances and security parameters in the physical space.

Fireworks simulation is emerging also as a new Audiovisual Art, where pyrotechnic expression is confined to a computer or audiovisual projection system.

The production of the fireworks simulation software Visual Show Director has been a long process of research of the many aspects involved in the simulation of fireworks as physical phenomena and also as a creation process and final perception.

APPROACH AND METHOD

How does Visualization work with Fireworks?

Fireworks Visualization: “Visual perception consists of the experience of visual forces”

Using the abstract concept of fireworks as movement of light particles. The particle animation software opens up new fields of visual, conceptualization and analysis experience.

Movement. Space. Time. Theme

Experience of Movement: Direction and speed/time

- The plasticity of the movement is controllable and transformable
- The coloration of the particles of light can be established within the full spectrum
- The quantity of particles in movement is predictable

Experience of Space: A 3-dimensional virtual world interaction

- The dimensions and proportions of the spatial model are known and controllable
- The implementation of reality from a frontal point of view is enhanced with 2-dimensional photographic backgrounds
- The 3-dimensional representation of the fireworks increases the perception of volume density and multiple viewpoints

Experience of Time: The sequence of events is displayed in real-time with a 1/30 of a second resolution.

- The duration of the effects is known and can be adjusted to the display resolution
- The order of the succession of events is perceived visually as in real Time
- The amount of particles present in the air at any moment is represented

Experience of Structural Theme: Dynamics; Order, balance, structure (sizes, distances, curvatures, and volumes)

- The perception of how elements interplay with each other
- The variations of rhythm in relation to effects duration and interval
- Dynamics is the very essence of visual perception

Movement

The primary source of movement is the firework effect itself. Fireworks effects can be created with the FX GENERATOR tool and added to Libraries for further use in the visual script. The control of Layers, Behaviors, Patterns and many other components, gives the flexibility to create from very simple realistic fireworks up to highly complex and innovative effects. The following parameters can be set for individual effects.

- Particle Types: Star Simple, Star with tail, Star with heavy tail, Star with dust, Rays and Glowing Tail.
 - Particle Size
 - Particle Color (14 million)
 - Particle Behavior: Color Change (5), Bee (erratic), Tourbillion (revolving), Strobe and Gravity Control
 - Particle Quantity
 - Particle Distance and random factor
 - Particle and effects height and random fact
 - Particle Direction
 - Particle Duration
 - Particle Distribution: Even to Random (empathy)
- or

The different effects can be applied in Layers at the same or different times, simultaneous or as a successive development. Delays can also be applied.

The visualization of the effects is three-dimensional and viewing is possible from any perspective. A Time and Particles counter give us a measurement of each stage of movement. The display can be paused and rotated for detailed analysis. The display of each stage of development of the effects can be isolated and displayed in memory as the process evolves. Snapshots of the animation can be taken for documentation of the visual effect characteristics.

Space

The perception of fireworks is relative to the position and firing angles and the spectators eye distance and location. Many different perspectives are possible from a 3-dimensional space. The distribution of firing positions also affects the aerial and the ground effects.

The software allows positioning firing locations in a three-dimensional coordinate system (xyz). It establishes exact distances with resulting proportionality of the staging areas and the fireworks effects.

Two dimensional relative backgrounds and three-dimensional models are the support for the positions. Any angle is possible to establish with tilt and orientation for each individual position.

Multiple editing tools for the treatment of positions are available; copy, paste, make arrays in linear, path or circular patterns, name auto numbering, change angles in xyz combinations for one or multiple elements.

Time

Time is of the essence to represent the fireworks simulation. The sound or musical score gives time normally. The effects successively interpret the mood and tempo of the music creating a specific dynamic for the display based on each musical piece. The duration of the effects and their lift time match the reality and are an important element to synchronize with the notes, and phrases of the music. The sequence of events is not limited to the duration of the effects overlapping in time. At any given moment we can see the amount of particles (stars) in the air. This gives us the possibility to correct redundancy, amount, density and distribution.

Theme

The many ways to structure a theme can be experienced with the succession of visual effects. The perception of the tempos and rhythms, the various emotions that each combination of effects produces along with the music, is part of the feeling and contemplation experience. We can see how the effects themselves and the elements of the composition interplay with each other, and how the intensity is distributed in the overall duration.

RESULTS (from intro)

1. The simulation technology adapted to the necessities of the Pyrotechnic Designer or Fireworks Manufacturer, is allowing us to join the rest of the scientific, industrial and artistic world. Using real time particle animation methods, we can now virtually represent the nature of the fireworks.
2. New types of effects have been generated and manufactured according to the visual specifications.
3. New types of dynamic patterns have been created with various kinetic expressions.
4. The control in the order and balancing of choreography has been increased with previous visual experimentation and correction.
5. The amount of pyrotechnic product visually disposed with the additional smoke screen and confusion during a show is reduced considerably or totally. The shows are produced with the right amount of material, not more or less than is wanted.
6. Fireworks simulation is emerging as a new Audiovisual Art, where the support for the pyrotechnic expression is confined to the computer or audiovisual projection system.

CONCLUSIONS

Such a support technology increases the visual experience and capacity of the designer. It is also a great educational tool for training, studying and learning. It allows the designer to show visual concepts and performances to others who may not have the abstract idea of what the composition is about. It allows the manufacturer to virtually design and rehearse new products and effects before manufacturing them.

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