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New Presentation System of the Tesla Long Island Tower Realized in Machine Language

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***Abstract*— This paper presents the chronological development of the Tesla's tower project on Long Island, from his first ideas and plans, the details of the realization of the plant itself, and finally the creation of a 3D model of the tower on Long Island realized by the new Polygene presentation system, written in x64 machine language by the author. This very long course of events covers a period of more than a century. The tower itself was built in the period 1901-1902, and the project of construction and improvement of the 3D model started in 2011 through several successive technological projects. The presentation Polygene system (2023-2024) is a modern continuation of this Tesla's 3D project.**

***Keywords*—** *3d modeling and simulation, Tesla's Long Island Laboratory, Machine language programming.*

I. Introduction

The first concrete ideas for the construction of a large transmission tower for wireless energy that will be built near New York, on Long Island originate from Tesla's stay in Colorado Springs in 1899 [9]. He came to Colorado Springs on May 18 in order, as he put it, "to construct a large power high frequency current generator, to perfect the methods of individualization and insulation of the transmitted energy and to determine the laws governing the transmission of currents through the earth and atmosphere". From June 1, 1899 until January 7, 1900, he made numerous notes which contain different measured values and calculations, many diagrams, remarks or comments regarding the daily experiments and the use of new configurations of instruments, apparatus and their interconnections [9]. His experience gained through experiments on the huge high voltage spark transmitter in Colorado Springs will be used to construct the world-wide communication system in Long Island.

Tesla publishes an article in "Century", the journal of his great friend Underwood Johnson in 1900, after return to New York [10]. The article draws the attention of the wider public due to the large number of scientific ideas on energy as an important aspect of our civilization. In this text, he foresees a time in which fossil fuels on our planet will disappear and analyses the possibility of using renewable sources of energy - water, wind and Sun. We have to mention that only four years after the start of operation of the Niagara Falls hydro-electrical plant, the first hydroelectric plant in Serbia started producing energy using Tesla's polyphase current principles.

The construction of the laboratory and tower for his "World-Wide Wireless System" started in 1901, based on the design of the famous American architect Stanford White. It was finished in 1902, but the tower never reached its originally intended form. According to Tesla's plan, the signals from the transmission tower were to be sent wirelessly through the Earth, which acts as a conductor, and can be registered anywhere on Earth. He envisioned the "World-wide System" as a global system of transmission of news and energy [9]. This was his life's dream that was never realized. On December 12, 1901, Guillermo Marconi sent the first radio signal across the Atlantic. He transmitted the Morse signal for the letter "s" from Cornwall in England to Newfoundland in Canada. The famous magnate and financier of this project, John Pierpont Morgan, withdraws the funding. Tesla writes a large number of letters to convince him to continue the investment into his project, but without success. He will finally leave Long Island in 1906 and turn to research and inventions in mechanical engineering. The abandoned tower was demolished in 1917 with dynamite, due to the suspicion that it could be used for intelligence purposes.

II. Project Computer Simulation and 3-D Modeling of the Original Patents of Nikola Tesla

Project Computer Simulation [1],[2] and 3-D Modeling of the Original Patents of Nikola Tesla started in April 2009 in laboratory CiitLab at the Faculty of Electronics in Nis, in the laboratory CiitLab, with close cooperation with Nikola Tesla Museum of Belgrade. The team of professors, engineers and students has accomplished a great success and results, which are implemented in presentation systems at the Nikola Tesla Museum, so that Museum visitors have the opportunity to see modern animation of Tesla's inventions. Through the project, the two institutions, Nikola Tesla Museum in Belgrade as an institution of national importance and Faculty of Electronic Engineering in Niš as a development institution, were linked in a common project for digitalization and modernization of Tesla's heritage.

The basic idea and aim of the project Computer Simulation and 3-D modeling of the Original Patents of Nikola Tesla is digital and detailed 3-D modeling of the original patents of Nikola Tesla, which are the part of the Museum's archives [8]. Using 3-D models, next steps were rendering, animation, simulation and visualization in real time. One of the most complex Tesla Laboratories that we have modeled is Tesla's Long Island Lab. Our model is complete, including main building and emit ion tower beside it. Also, all machines,

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generators and other moving structures inside the building are animated.

The project had a number of promotions, scientific papers, seminars, and media attention in period after 2010. To crown the success is a joint appearance with the Museum of Nikola Tesla at the World Exhibition in China in 2010 at the central stand of the Republic of Serbia. 3-D movie for the occasion was made especially seen by some 200,000 visitors and in New York, on 6.1.2013. in the seminar *Why Tesla Matters*. All materials are linked on Nikola Tesla Museum internet site. That is World-wide promotion of our project (https://tesla-museum.org).

A. Long Island Virtual Reality (VR) model

The Virtual Reality (VR) model of Tesla's largest laboratory was developed on the basis of 6 original photographs from the Nikola Tesla Museum using the technique of direct (manual) 3D modeling [3]. The model was basically developed for desktop PC environments but was later modified and completely redesigned for the needs of the VR Samsung environment (Samsung Gear with compatible Samsung Galaxy phones, models S7, S8, S8+, S9, S9+, A8, A8+, Note8, NoteFE) [3],[4]. The model has been thoroughly improved and optimized several times and currently the latest version works on S8 phones with exceptional VR performance. The application uses full hardware resources of the phone and is among the most complex models developed in the world for this VR platform. The VR Long Island model is specially optimized for speed, because it works with split maps (special VR models), which is an innovative approach in this kind of complex VR applications. Movement through the VR model is much faster compared to the standard integrated model, but since the model is divided, the transition from one room to another (or from the outside to the inside) takes place through the transition areas - the central corridor or the main entrance door. So, the communication between all the rooms is solved simply, from the central corridor by passing through the half-open door (main room, boiler room, workshop) and the exit outside is the main door of the main room [5],[6].

When starting the model, there is a certain initialization period and the entry point after loading is in the middle between the tower and the building. The basic path of movement is:

1. Climbing the stairs to the top of the tower,
2. From the top, a direct transition to the main room (marked in the middle of the tower),
3. Central corridor,
4. Boiler room,
5. Basement,
6. Central corridor,
7. Workshop.

Movement for the standard VR model is solved using the buttons on the helmet: a) Lightly touch the touchpad to start movement b) Volume up - start, Volume down - stop on the VR helmet. The following picture (Fig. 1.) shows the basic plan of the Tesla Long Island VR laboratory:

Fig. 1. The basic plan of the Tesla Long Island VR laboratory (Workshop -top of the image, Boiler Room-left, Main Room-bottom).

In the latest version for S8 phones, control with a gamepad is enabled, which makes movement much easier, In case of any problems, there is a software restart option that reloads the application and sets the entry point for the tour. A Bluetooth keyboard is used for this.

The modeling was done in Maya software based on the original photos of Nikola Tesla's patents from the Nikola Tesla Museum. Model optimization for Samsung Gear VR was also done in the same software [3]. This is a crucial step due to the limitations of the phone. After this, the models were transferred to *.fbx format suitable for 3D-Engine and transferred to Unreal 4 Engine [4],[7]. Based on this, a scene suitable for implementation in a VR environment was created.

The model consists of several main sectors that are divided as separate models for performance gains (Fig 1). These sectors are: Main room, Boiler room, Workshop, Tower and surroundings, Basement with a large coal-fired water heater (modeled and integrated into the main VR Long Island model in the 2017 project).

In the case of the version with maps, all elements are connected by Unreal functionality, while in the desktop version there is no division - the model is integrated.

III. Phases in Construction of Tesla Tower

In order to illustrate the creation of the idea, the materialization and digitization of the Tesla's Long Island Tower through our project, we will present a sequence of key moments. The stages that we will show are chronologically connected and represent all major steps that led to the construction of our final Long Island 3D model.

Tesla's preliminary idea of the appearance of the tower (before it was built) is shown in the illustration in Figure 2:

Fig. 2. Tesla's first idea about the appearance of the tower (Nikola Tesla Museum heritage).

Tesla then made the first technical drawing, with the intention of patenting the construction the tower itself (Fig. 3).

Fig. 3. Draft patent application for the appearance of the tower (Nikola Tesla Museum heritage).

The next stage was the creation of a technical drawing, based on the inventor's idea. Fig. 4 shows the technical drawing of the tower construction with exact dimensions.

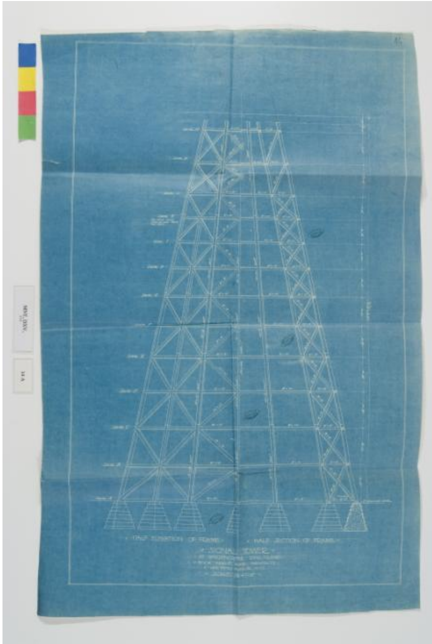

Fig. 4. Technical drawing of the Long Island tower (Nikola Tesla Museum heritage).

Finally, the tower was built together with a low-rise building that housed the laboratory (Fig. 5.) and which we modeled in detail in a 3D and VR environment (Fig. 1.).

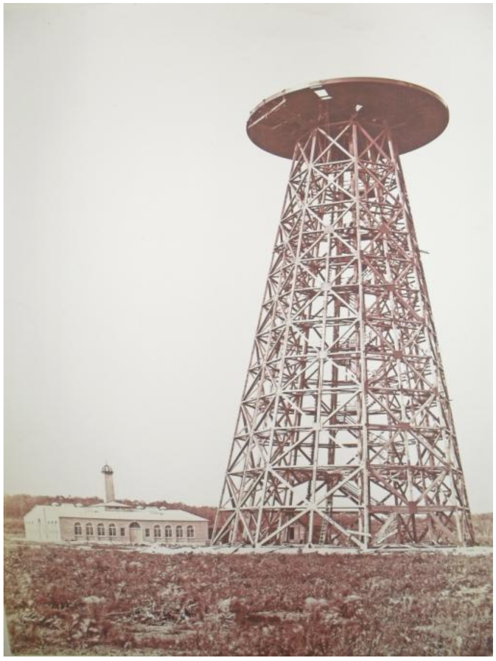

Fig. 5. View of the construction of the tower and auxiliary building of the laboratory, without the dome/electrode that was erected at the very end of the construction (Nikola Tesla Museum heritage).

As we have already mentioned, the tower was demolished in 1917. However, thanks to the precise photographs of the laboratory and the tower that Tesla had taken during and after the completion of the works, we had enough information to reconstruct them. In this paper, we focus on the tower itself, so we will show the basic elements of its modeling.

The first step is manual production according to the photo in one of the 3d modeling programs (*Autodesk 3dsmax* and *Maya* were used) [7]. Details of the construction of the wire model are in Fig. 6:

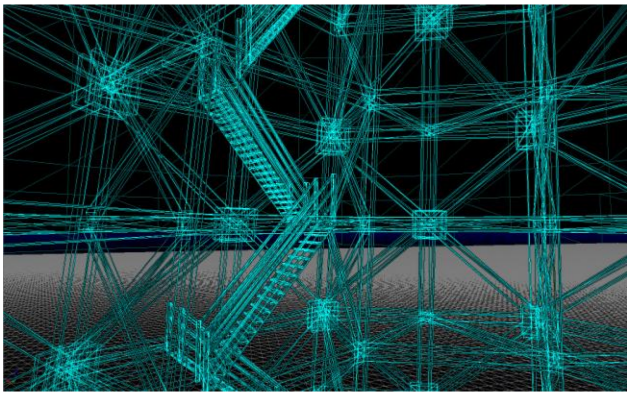

Fig. 6. Construction details of the Autodesk 3dsMax wire tower model.

The wireframe 3D model shown in this image is edited manually, and it is extremely important not to create any distortion or asymmetry. The complete picture is shown in next figure:

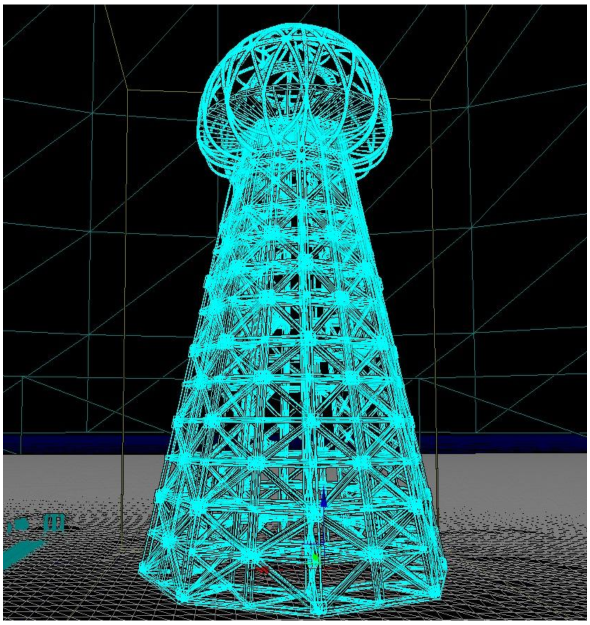

Fig. 7. Complete construction of the tower - wire model.

The next phase is materialization, defining surfaces and materials on the model. This is done in *Unreal engine* (Fig. 8.). Through several iterations of the model, a complete working model is finalized, which can go into exploitation.

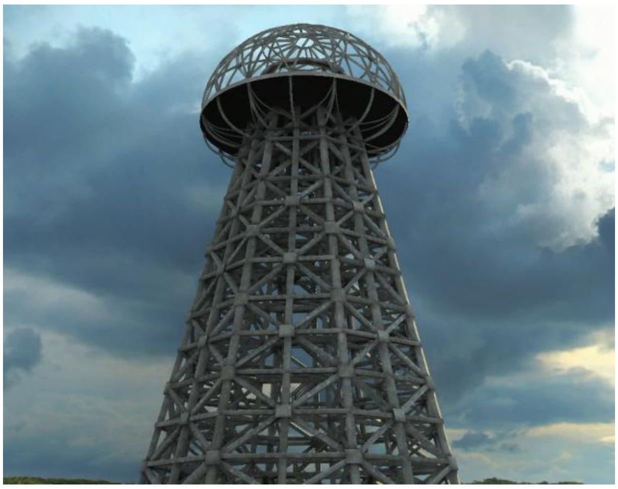

Fig. 8. Materialized model of the tower.

The final phase remains, adding details of the environment, experimenting with materials, and completing the model (Fig. 9.).

Fig. 9. The model of the tower integrated into the wider model with the environment and the laboratory (prototype).

At the very end of the modeling phase, the complete Unreal model is carefully adjusted, including the precise arrangement of all objects, materials and colors, and thus we get the final version of the model (Fig. 10.)

Fig. 10. Final Unreal version of 3D Long Island model with tower.

IV. POLYGENE PRESENTATION SYSTEM

Polygene is an environment for developing highly efficient applications for the X86 environment, intended primarily for real-time work. It was written by the author from mid-2023 and is a novelty for this class of environment. It is done in a structured programming system that is defined within the *Delphi 7* environment (oriented towards the programming language Pascal) and which relies on a library of very fast machine routines that are an integral part of the system. The code is universal based on 32-bit machine instructions, and is vertically compatible with all PC hardware platforms and operating systems. The system is extremely compact, producing a single .exe file. During the development of new procedures, the entire Polygene system is compiled in one pass so that the constant cohesion of machine procedures is ensured. It does not use an object-oriented approach or external libraries of any kind. Therefore, Polygene is a closed program system.

A very important characteristic is the tendency to bypass drivers and work directly with the hardware. Of course, it goes without saying that ready-made libraries offered by Delphi itself are bypassed, except for those that are basic for the operation of the entire system and for certain purposes (for example, for UDP and TPC/IP communication). In the graphics part, Delphi's otherwise rich graphics system is almost completely bypassed (except REPAINT function).

Working with graphics is maximally simplified in the Polygene system. The screen is displayed as a series of RGB pixels to which the byte of the highest weight is added, so that the entire pixel is stored and processed in one 32-bit register. All the pixels on the display are stored in their natural order and are remembered in the form of a simple sequence:

mMASTER:array [0..rscrxy] of integer;

Where **rscrxy** is a constant that determines the capacity, based on the maximum resolution.

In this way, the manipulation of pixels is reduced to the manipulation of 32-bit integers, and can be left to the x86 machine code in the most efficient way possible. As an illustration of the operations that take place through the Polygene system, we present a machine routine whose function is to scroll the display for an arbitrary number of positions to the left.

It should be noted that during machine programming in the Delphi programming environment, we can change the EAX, ECX, and EDX registers, but must preserve the values of EBX, ESI, EDI, EBP, and ESP.

Key functions are commented directly in the code. Following hybrid Pascal/machine code is the model of constructing the Polygene library of assembler routines.

```
procedure mem_scroll_left_with_STEP(m,from,VERT:integer);

begin

mem:=from+4*(VERT mod MAXX)*STEP; {calculation of mem
pointer}

asm
  push ebx   {preserve registers}
  push esi
  push edi
  push ebp

  cld
  mov ebx,M      {destination memory pointer}
  mov edx,[MAXY] {Y resolution - 1080}
  MOV EBP,[MEM]  {source memory pointer}


@lpy:
  mov edi,ebx   {pointer calculations}
  mov esi,edi
  mov eax,[STEP]
  shl eax,2
  add esi,eax

  mov ecx,[MAXX]    {x resolution - 1920}
  sub ecx,[STEP]
  REP MOVSD         {move display pixels, PIXEL BY PIXEL}

  MOV ESI,EBP
  MOV ECX,[STEP]    {move border pixels}
  REP MOVSD         {scroll left!}

  add ebp,[MAXX_RAW]   {next raw}
  add ebx,[MAXX_RAW]
  dec edx
  jnz @lpy  {loop}

  pop ebp   {reload registers from stack}
  pop edi
  pop esi
  pop ebx

end;
```

This machine routine shows that it basically uses the super-fast machine instruction REP MOVSD to switch integers representing pixels. Since the video memory (on the graphics card) is not used in this process, everything is processed in the operational memory, and with the use of super-fast machine commands for calculation with integer arithmetic and linear movement of data, the maximum performance of the Polygene video subsystem is achieved.

The control panel of the Polygene system is very simplified and only the basic functions are provided (Fig. 11.):

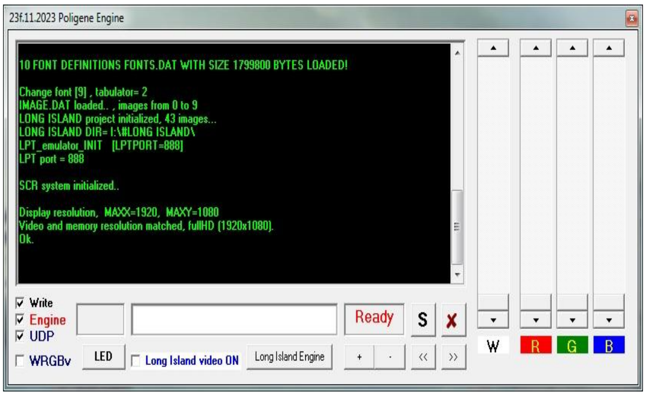

Fig. 11. Polygene system control panel.

Key functions: *Long Island Engine* - start the presentation, *WRGB* controls the colors, *UDP* turn on distant LED controller. The user can also use the cursors to change the direction and speed of rotation (+,-) of the Long Island model. Option (*Long Island video ON)* switch on animations of Tesla machines, in some defined positions of the 3D model. The original uncompressed video format that has the maximum quality is used. The USB3 or SATA III buses have sufficient speed for supplying assembly routines with large video sequences.

One of the first implementations of the Polygene system is Long Island, which consists of a series of 43 specially processed 360 degree images, which are extracted from the Unreal model. Video animations of Tesla machines are also included [5]. The audio that accompanies this automatic presentation is an integral part of the materials of the Nikola Tesla Museum. In this way, a high-quality hardware-independent and efficient presentation system was realized that can work in automatic or interactive mode. In this sense, it is extremely useful for the needs of museums or similar institutions.

The central part of the presentation is the Tesla Tower, which was described in the earlier part of the paper. The first presentation of this system was shown publicly on November 24, 2023. on the Day of the Faculty of Electronics in Nis.

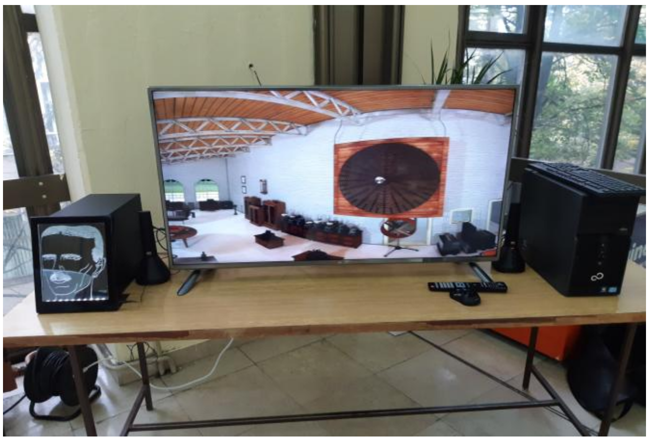

Fig. 12. First presentation of the complete system (November 2023).

V. Conclusion

This paper shows the basic structure of the author's new presentation Polygene system written in machine language in the Delphi environment. The system is primarily intended for exploitation in real time, when performance is extremely important. The software environment uses the maximum potential of the hardware. It is independent of drivers and other operating system details. It works on a huge range of PC configurations and Windows operating systems.

Future work will be focused on the implementation of this system in institutions of interest for preserving Nikola Tesla's heritage, such as the Nikola Tesla Museum in Belgrade. There is still a lot of room for additional optimizations within the machine core of the Polygene system and a very wide field of application to other 3D models. Also, it is planned to develop an interface that would recognize the position of visitors' hands, which would determine the direction of the animation in this way, without physically touching the equipment.

Acknowledgment

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