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# AC Electromotor Construction by 3d Modelling and Cluster Rendering

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***Abstract* –In 1882, Nikola Tesla discovered the rotating magnetic field, a fundamental principle in physics and one of the greatest discoveries of all times. In February, 1882, Nikola Tesla was walking with his friend through a city park in Budapest, Hungary. Tesla was reciting stanzas from Goethe's Faust, the sun was just setting, when suddenly the elusive solution to the rotating magnetic field, which he had been seeking for a long time, flashed through his mind. At this very moment, he saw clearly in his mind an iron rotor spinning rapidly in a rotating magnetic field, produced by the interaction of two alternating currents out of step with each other. One of the ten greatest discoveries of all times was born at this glorious moment. Tesla was gifted with the intense power of visualization and exceptional memory from early youth on. He was able to fully construct, develop and perfect his inventions completely in his mind before committing them to paper. From his memory he constructed the first induction motor. Tesla's AC induction motor is widely used throughout the world in industry and household appliances. It started the Industrial Revolution at the turn of the century. Tesla's electromagnetic motor is based on the principle of rotating magnetic field. This great idea and today could be visualising with new computing modelling and simulation technology. We do one step forward that to show details about tree phase AC motors first of all inspirited with educational motive.**

*Keywords* – **AC Motor, 3d Modeling and Cluster Rendering**

## I. INTRODUCTION

Computer modelling and simulation now plays a very important role in development of new processes, structural modelling and technical systems in order to make them as safe, efficient and reliable as possible. As science and systems increase in complexity, so does the amount of computation required to model them effectively. These scientists and educators will be able to use the ICST (Information Communication Scientific Technology) infrastructure, computing power and visualization to do further their research and education.

New computing visualization is an interdisciplinary field, which can only flourish when computer graphics experts cooperate with specialists from application areas, and providers of computing, visualization, and data management facilities. [1]. It will be able to drastically enhance their scientific research and data visualisation for experimental/scientific use (enhanced human-computer interaction, enhanced high-performance and high-throughput computing), as well as for presentation, dissemination and education.

Technical visualisation technology will enhance the productivity of many areas of research and industry which heavily depend on complex computer models of the nature and processes. These objectives will be achieved by renewing the scientific/technical visualisation technology with new visualisation methodology using cluster computer infrastructure and POVRay image programming support

## II. IMAGE MODELLING PROGRAM

For the Tesla's AC motor modelling application we decided to use a shareware program POVRay1 which uses the calculation technique by means of air for creating 3D computer graphics with the photographic quality. POVRay packet is free for usage on different platforms and operation systems (UNIX, MS Windows,.). Because of the usage freedom, easiness to use and simplicity, it is spread and often used program for drawing [11]. There are supported versions for MS Windows OS, Mac OS and Linux OS operation systems. POVRay presents the tool for image "presenting programming". Image is represented by the program code which during performing generates the image in BMP, TGA (Targa) or some other supported format. To use POVRay means to learn its language for object image presentation.
Ray tracing is the method for image generating based on mathematical description of the image contents. Mathematical functions are based on modelling the relationships among the light, position of the camera and object. The scene is described by Scene Description Language (SDL).
POVRay reads the textual database during the work with the user's commands and as the output it gives 3D computer

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[*]POVRay abbreviation from Persistence Of Vision RAYtracer

image. The textual database contains the type of light, observer's position, texture of the object (outlook of the "surface" of the graphic image which gives the apparent impression of the physical substance: metal, glass, wood etc.) atmospheric conditions, outlook of the object etc.

POVRay is in fact the code programming image presentation and in that manner it is a very powerful solution for scientific visualization. The best thing about it is very strongly mathematically deep-seated. The good thing in this program is so called the Constructive Solid Geometry (CSG) approach. To explain it with simple words, it means that your object can be presented as the union of other objects as well as the cross-section or difference of objects. In this way it is possible to "statue" mathematically your object using the basic objects which POVRay recognizes (sphere, cylinder, quadrangle, prism, cone, tours, 3D text, equi-surface, polygon, high altitude field, plane and many others). Objects can be defined so that they look as if they were built of "real" materials. Their colours can be defined, their letting the light through and reflecting the light and the knottiness of their surface. The position of camera can be defined, and the "scene" can be looked at from various different angles. Several different light sources can be set, atmospheric conditions can be defined in the space where the objects are. The language of POVRay understands and uses huge quantity of mathematics. Its routines can be defined (so called macros and functions) which will do the determined calculations. We could do macro which positions the objects in the scene according to the determined regulations or some other macro which sets them in the position in the crystalline grid. The only disadvantage of POVRay is that it cannot produce interactive visualizations.

Standard colours is described by 3 RGB vectors. It is possible to obtain partly transparent colours, pigments specifying the colour such as colour RGB <1,0.2,0.1,0.8>

Number 0.8 says that the colour, pigment, i.e. the object on which it is applied lets 80% of light through, which means that the object is partly transparent, "glassy" or similar. Generally speaking the "colour" is specified by 5-vector (rgbft) as the colour rgbft <1,0.2,0.1,0.5,0.8>. The fourth component specifies the quantity of the"filtrated" transparency, i.e. the light passing through the object gets partly (f<1) or completely (f=1) the colour of the object. The shortened form rgbft denotes red green blue filter transmit rgbt shortened form means red green blue transmit. The program calculates always with 5-vectors, if filter and transmit components are not specified sets them to zero.

The application can be used for animation of the scene. The key for this usage is the reserved clock variable of the POVRay language. By using this variable you can position (rotate, translate, show, hide, scale) your objects dynamically. In this case POVRay generates each frame of the programming animation as a series of stationary scenes. Connecting the generated (calculated) stationary scenes (or frames) into the continuous flow results in film (this operation must be done outside the POVRay). The simplest version of animation is the one in which 3D coordinate describing the scene, are credited by the time dependence ("motion" of characteristic coordinates). The time dependence in POVRay is specified by the scalar variable clock. In this way the uniform motion of the sphere along the axis x could be written as sphere {<0,0,0>, 1 translate <4*clock,0,0>.}The interval in which the variable clock changes as the number of images (frames) which are necessary to be generated within that interval are typically given in file separated from pov file which describes the scene, in the short initialized file (ini) which contains reference on pov file scene. If we want to produce the animation we process .ini file by POVRay compiler.

## III. Modelling and Simulation

Model has been started in program kpovmodeller (www.kpovmodeler.org) on operation system Linux (www.linux.org), and after this it has been transferred to POV-Ray 3.6.1 (www.povray.org) ray tracing rendering system. To enable "scalability", applying this meaning to dynamic change of the dimensions of model by the means of parameters and variables, initial model has been returned to primitives, exported to POV-Ray SDL language, and reverse engineered from numerical model quantities to variables.

Animation has been rendered on a cluster system produced at the Chair, which enables use of Linux, Mac OS X and Windows/Cygwin machines together in the cluster. Typically, 3 to 8 machines were used with varying hardware and operating system to support rendering.

Final shape of the animations (animated GIF images) has been fixed in Imagemagick 6.2.6-4 (www.imagemagick.org) software, offline. Then additional optimization was introduced using GIMP 2.2 (GNU IMage Manipulation Program, www.gimp.org), for faster download. Optimizations consisted mainly of colour reduction in animation with minimal perception impact of animation quality, and of special optimizations for better compression. It can be satisfied acknowledged the success to complete entire development and animation production cycle with Open Source, free and GNU programs, which under a challenge to the skill and knowledge of explorer offers development platform for production of education materials and advancement in teaching also for undeveloped, and for poor countries.

Additionally, the fact open source is used enables interactive and online use for contraction of complex models via CGI gateway software by students, which is impossible to produce with commercial animation design software, or would result in copyright infringement.) In the spirit of the system being built on open source and GNU platform it is logical to offer our GRC (Graphic Rendering Cluster) under the same conditions (GNU General Public License). Unlike great clusters with few tens or hundreds of symmetric and multiprocessor computers, this platform enables for construction of a "garage cluster" from heterogeneous components with still smaller demands on equipment. Use of FCFS (First Came First Served) task distribution algorithm enables even very slow machines to still contribute to the processing power of the cluster, so even abandoned computers can be used. AC motor Modelling address is: http://magrf.grf.hr/~mtodorov/tesla/build_3ph_induction.html

## IV. Conclusion

Promotion of e-Science infrastructure usage can allow all researchers and educators to attain a new level of scientific and technical understanding and presentation, thus enabling both genders to further their scientific endeavours. Image programming for scientific and technical visualization by cluster and Grid computing is a perspective roadmap.

We will soon be able to increase the number of the client computers in order to gain more processor power needed for accelerating the processing of all given materials using the SEE GRID infrastructure facilities. This modelling solution as an example of the "knowledge is money" principle, because the investment of efforts and skills results comparable with commercial systems can be achieved, or even more functional: as seen on electromotor contraction demonstration page, it is possible to build a CGI rendering gateway with possibility for students and class attendants to change model parameters in an interactive way, even such parameters as number of stator and rotor poles, number of coil windings and other parameters, with default automatic resizing of model dimensions, which adapts automatically to a reasonable number of poles such as 60 or more. Increase of processing power level could be reached where students and class attendants could develop their own animations online, changing model and animation parameters. Behind animation, a mathematic underlying base for simulation should be established, so the real and physical aspects of electromotor simulation could be understood and simulated by students, producing new level of understanding Tesla's inventions, using much more powerful tools than board, talk and paper.

## References


[1] Y. Le Lous, "Report on the First Eurographics Workshop on Visualization in Scientific Computing", *Computer Graphics Forum* **9**(4), pp. 371–372 (December 1990).

[2] http://dcc.irb.hr/

[3] http://sisuite.sourceforge.net/

[4] http://www.clusterresources.com/products/torque

[5] http://www.csm.ornl.gov/torc/C3/

[6] http://www.openldap.org/

[7] http://ganglia.sourceforge.net/

[8] http://www.isc.org/index.pl?/sw/dhcp/

[9] http://www.shorewall.net/

[10] ftp://ftp.mamalinux.com/pub/atftp/

[11] http://www.povray.org/