

Exploration of Virtual Reality Modelling Language world and its didactical applications.

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Abstract: This paper presents an overview of Virtual Reality Modelling Language (VRML) abilities for didactical purpose. To address meaningfully the challenges of the VRML utilization, some trans-disciplinary aspects are highlighted in this study. One could note that VRML should be seen as a crossroad among different scientific and non scientific fields such as electronic, automatics, mechanics, mathematics and physics, architecture, and graphic arts. It can be used successfully in deep study, whatever the scientific level and origin of the students: secondary school pupils, undergraduate, postgraduate students or engineer school students. After a short presentation, this paper focuses on various application of VRML from psychological, artistic as well as technical point of views. An original comparison with CAD electronic software tools is done in order to help the understanding of VRML world, pros and cons are explained. Further, we give some technical details and concrete hand made examples which can be used as course material, and finally we emphasize the conclusion on our findings.

Key words: VRML, 3D modelling and animation, Student's psychology, Didactical applications

1. Introduction

"Virtual Reality Modelling Language"(VRML) was coined in 1995. Initially, it was emerging as a need of people who wanted to make three dimensions drawings and virtual animation for didactical and/or scientific purposes [1], [2], [3]. VRML can be considered like one of the "fathers" of the most popular and modern 3D design software's tools.

For example, VRML is one of the basic file format of the graphical interface modules included in the well known software such as BLENDER or MATLAB/SIMULINK. With this last software, it is thus possible to visualize simulation results as 3D virtual animation.

Nowadays, there are voices claiming that VRML should be considered as obsolete, emphasizing a lot of modern and up-to-date software's tools able to do better and easier.

This is the reason, the main following enquires are discussed in the first section of the paper:

1° Why still having consideration for such a quite old language?

2° What kind of utilization for VRML and what benefits could we expect when working with VRML today?

Paragraphs 2, 3, 4 propose some answers by focusing on psychological, academic and scientific aspects.

In the second part (§ 5, 6, 7), we give technical details on VRML use.

Finally, in the last part, (§ 8), we suggest some possible hand made didactical applications adapted to various student's level and fields of studies.

2. Some psychological and intellectual aspects linked to VRML use

To understand the most important psychological impacts of VRML use, it is first necessary to investigate some useful general considerations on the brain behaviour. For that purpose, a classical "brain" modelling and student's behaviour are discussed hereafter.

2.1 Herrmann brain behaviour modelling [4]

Ned Hermann, was a past manager of the formation in General Electric Company. He developed a technique making it possible to easily know the cerebral preferences and mental behaviour of an individual. At the beginning, this method was used to improve the efficiency of industrial team work by an optimized

team constitution. Depending on the goals of each team (commercial, technical, management, etc) the association of perfectly chosen profiles was the guarantee of an effectiveness work.

Today, this universally recognised method is intended for better understanding the preferences of an individual, his way of reasoning and his approach to particular problems.

It results in a representation of the human brain into four quadrants which correspond to the main four preferences of the individual as indicated in Figure 1.

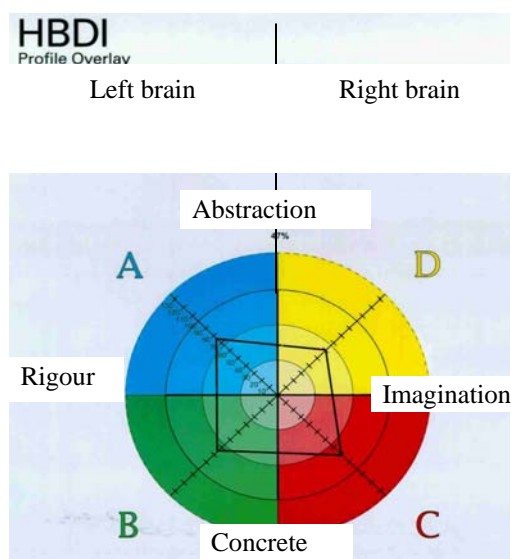


Figure 1: Herrmann diagram.

Quadrant A (blue) shows the preference of the individual for logic, modelling, (typical profile: mathematician, data processing specialist ...)

The quadrant B (green) reflects the aptitude for the practice and planning (real time production scheduler, administrative profile...); the quadrant D (yellow) shows the preference for the risk and projection in the future (typical profile: "start-up" manager, risk manager, artist...), and the quadrant C (red) emphasizes the preference for the relational one, feeling, emotion (typical profile: social and commercial workers...).

32 different profiles [5] have been identified equally found in the population. In addition, we can say that is no good or bad profiles; there are only different profiles which can be with mono or multi quadrants dominating.

2.2 Application to traditional academic learning process

If one superimposes the traditional diagrams of teaching scientists (course, training, practical lesson) on the diagram, one realises that the process of

training addresses only the left brain whatever the approach "top bottom" (theory towards the practice) or "bottom up" (practical towards the theory).

Consequently, the affective and emotional aspects, in scientific cursus are often ignored.

A similar reasoning can be done for traditional teaching in business school or social science which operates almost exclusively with the right brain.

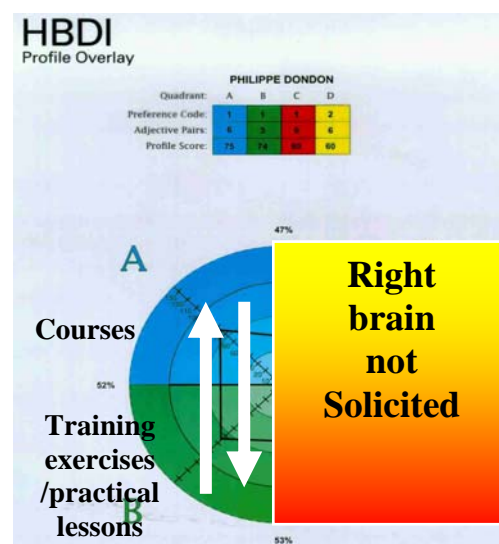


Figure.2: Traditional scientific pedagogy

2.3 Impact on students learning

Unconsciously, a mono dominating "left brain" profile is more attracted by scientific studies while a mono dominating "right brain" student is naturally attracted by artistic and social activities.

However, due to the high number of various Herrmann profiles among the whole population, we obviously find mixed and balanced profiles in the both main fields of study.

So, what happens when a mixed brain profile student starts scientific studies or social/business studies?

This kind of students needs at the same time, a rigorous scientific approach and a more intuitive or artistic approach. This requires a specific attention from teachers. Otherwise, it can lead to an unhooking, incomprehension or lack of interest of these students [6].

2.4 Other aspects of student's behaviour

During the past 40 years, important changes in student's behaviour have been observed everywhere in the world. The concept of "generation" has already been theorised by N. Howe and W. Strauss in 1991

[7]. Teachers are now facing a new kind of public (called the “Y generation” [8] born between 1980 and 1990 -i.e. “the mobile phone and iPod” generation- and “M generation”, born after 2000 –M for “Multimedia generation”). Evolution of mental and physical behaviours is observed and it generates a lot of questions for philosophers, doctors, scientists. Some of these evolutions have direct impacts on Education field. In particular, we can highlight the uses of video games, internet and I-phone with sometimes excessive or addictive behaviours.

These new behaviours have possible positive consequences but also negative aspects: Whatever the level (primary, secondary school or university), we observe often an excessive mental dispersion, a lake of concentration with “zapping” phenomenon, and a loss in terms of culture.

Some specialists worry a lot about internet excessive use. Indeed, easy and immediate access to any information dot not requires anymore memory training. Some doctors speak about a possible deep neuronal long term modifications in the brain since the memory is less solicited.

Unrespectable or aggressive behaviours towards teachers are also possible consequences of the evolution.

2.5 Brain stimulation with VRML

VRML belongs to this kind of “tools” among others (like yoga, meditation for human aspects) who are able to answer partially to psychological questionings and observations, as we highlighted in the previous paragraphs. Indeed, VRML can be considered at the crossroad of all the brain’s quadrants; by essence, VRML is a structured informatics language which solicits the logical and rigorous way of minding (Blue quadrant). Drawing animated 3D objects requires mathematical and general physic’s competencies and a good level of abstraction.

But, it also solicits imagination, creativity and artistic approach to draw an object and to produce scenarios (Yellow quadrant). At last, it requires a “concrete brain” to make practical applications (Green quadrant) and “social links” (among other) to compare VRML experience within VRML community (Red quadrant). Thus, VRML can be seen as a federating tool which can be used a wide range of profile for a wide range of applications.

Lastly, construction of objects in 3D is a specific brain training that oblige to a high mental concentration during the design phase. It is thus a way to use (and to

play) PC computers tools while trying to fight against mental dispersion of students.

3. Understanding VRML world by comparison to CAD electronic tools [9]

One of the difficulties of VRML is to be a computer language created by computer specialists with a specific vocabulary which is not easy to understand for non specialists. There are a lot of excellent WEB sites [10], [11], [12] with “on line” courses for those who already know basics in programming language.

However, before using VRML, it is first necessary to become familiar with the some abstract concepts and VRML vocabulary.

In order to facilitate the understanding, we suggest here a transposition or a parallel between CAD Electronic fields (our initial culture) and the VRML world (cf. table 1).

Moreover, SPICE and VRML can be interfaced as follows:

The results obtained after a « transient » SPICE simulation are available in a table of value which contains for each instant « t » of the time simulation, the value of all electrical nodes (voltage and current) of the circuit. They are stored in a *.dat file. After some adaptations, this file can be included in a *.wrl file, using the « *interpolator* » instruction. It is thus possible to make a 3D animation representing a phenomenon previously simulated with SPICE.

At last, we must mention that the same process is possible starting from EXCEL spreadsheet or MATLAB/SIMULINK.

Electronic CAD	VRML world
Design and simulation of an electronic circuit	Design an animation of any objects (house mechanical part, landscape...) in 3D
Basic components : R (resistor), L (inductance), C (capacitor), T (transistor)	Basics components: Box, Cylinder, Cone, Sphere
SPICE modelling of a component = (list of parameters : leakage current, parasitic capacitance, thermal coefficient etc.)	Basic shapes attributes: (Colour, intensity, texture, transparency...)

To give a name for a component: R1, C16, etc.	To give a name for a object: (<i>DEF...USE instruction</i>)
Description of a circuit (association of several components) in text file format. *.cir (SPICE Netlist)	Description of an animated object (association of several basic shapes) in text file format *.wrl
Bias point (DC voltage and current values) V, I,	Initial position of the object in the 3D references axis (<i>Transform, translation, rotation instructions</i>)
Hierarchical Schematic: For complex multi level circuit, a "top" circuit can include several sub circuits files. Each of them is described in a *.cir included in the top level *.cir file	ranked scenario: to draw a complex scenery (for example, <i>landscape including several villages including themselves several houses including furniture ...</i>), a *.wrl files can include several under *.wrl files, like Russian dolls
SPICE "transient" simulation .TRAN t_o , t_{max} , t_{step}	Transient animation of the drawn objects (<i>interpolator instruction or java script</i>)
Results (curves) displayed in a visualisation windows	Visualisation of the movements with a « plug in » Cosmoplayer for in internet navigator, or Orbisnap [13]
Schematic capture software (ORCAD/CADENCE, EAGLE, PROTEUS etc.)	Any 3D drawing software (Blender, Autocad, Solid works, etc.) with VRML exportation option

Table 1: VRML SPICE comparison

4. VRML Pro and con's

After the explanations given in the previous paragraphs, we can now answer to the questions we set in Introduction:

Thus, VRML is regarded by some as obsolete, outdated and certainly far outdated: There are obviously now better and ergonomic software's to draw the objects since the graphical interfaces have made much progress and there is no more plug-in for the latest release of internet navigator.

Outdated? In a certain one sense, of course Yes... because using VRML today to compete with the aesthetics, ultra realist video games would be like wanting to create a complex 100,000 transistors circuit by describing it line-by-line in a *.cir text file: that is to say, extremely fastidious and almost impossible. So, we must look for the advantages of VRML elsewhere:

1° To know the evolution of the tools that human use for thousands of years, is interesting from a cultural and historical points of view (where historical means history of Science). Indeed, without this knowledge, understanding and using modern tools skillfully is not always simple. For example, to use a modern electronic simulator (simple click on a button to run the simulation) without knowing how it happens "behind", without knowing the meaning of some parameters or the general philosophy may lead to errors or dysfunction.

It is the same with the use of a word of our language without knowing its roots: it can lead to a more or less comic misunderstanding.

And it is also similar to the farmer who knows the use of the pickaxe and ploughshare: he will use its tractor intelligently.

2° Due to its hardness (only 4 possible basics shapes), VRML is a great stimulator of creativity and imagination: Indeed, how to draw a mechanical part, a building, a boat, a landscape, or any kind of objects of the daily life, with a library of shapes so reduced? (cf. figure 3). In addition, the description of an object as line of text, oblige the brain to spatially imagine the object and its position before its construction.

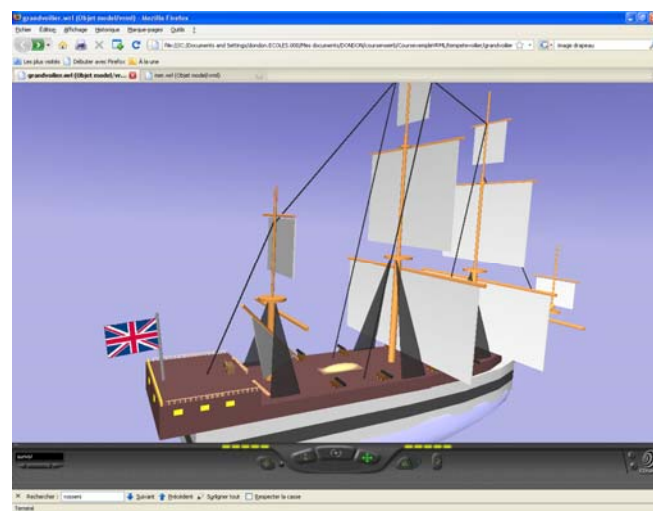


Figure 3: Old ship drawn only with the 4 basics VRML shapes

In this way, it is a true "brainstorming" that brings us closer to what our seniors called "descriptive geometry", with the study of curves, surfaces, volumes and their intersection in the space.

3 ° The VRML allows also to focus on the general knowledge, for example to the color management: in this way, it deals with graphics and concepts of basic optical, primary colors, additive and subtractive synthesis to obtain various colors, TV colors on LED screens. In short, it is an opportunity to stimulate the curiosity for many related scientific areas.

4° Animating objects in VRML do not work like in cine film. Movements must be described in VRML as mathematical equations. Thus, programming in VRML allows to apply various mathematical notions such as reference axis changes, translation, rotation, classical mathematical functions (geometry, trigonometry etc.) and also physical basic laws (kinematics, uniform or non uniform movement, solid equilibrium in translation, in rotation, etc.) taught in college and after. A concrete visualisation of physical phenomenon and its equations can be helpful from a didactical point of view.

5° We must not forget that VRML is a free language and usable by anyone of us, in particular, for those who do not own heavy and expensive tools. In that way, we can say that VRML is a sustainable development tool. At last, one can find a lot of WEB site dedicated to VRML with gallery [14] of objects and forum discussion.

In short, as long as you do not use VRML for creating sophisticated video games with a hyper-realistic graphics or an animated film, you can learn a lot, have fun or work seriously, and visualize complex SPICE or MATLAB simulation results for scientific or didactical purpose.

5. VRML files hierarchy and structure

As said before, VRML is a hierarchical structured language. A typical *.wrl file looks like a text file that can be edited with simple text editor. It is built as follows:

The "description block" contains a set of instructions to draw for example, a mechanical or an architectural part, a landscape or any kind of object. The drawing is based on the four basic shapes: box, cylinder, cone and sphere with their attributes size, colour, brightness, transparency, scale factor and 3D location.

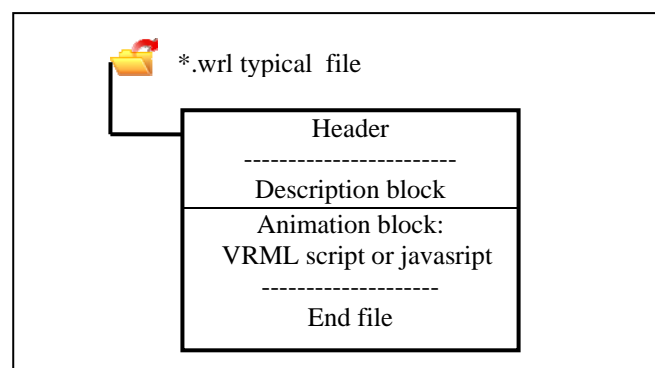


Figure 4: Typical VRML file structure

The "animation block" contains a set of instructions to move the drawn object (Cf. details in § 6.).

A Sub-VRML file can be included in a VRML Top level file to make complex design. In the following example (old sailing boat shown in figure 3), the Top level file (the whole ship description) contains the following sub files describing elements and sub parts of the ship:

- The main multicolour shell,
- The lower and upper decks,
- The four mains mast,
- Wood stairs,
- Cannon (multiplied by 6),
- Protection rails on upper rear deck,
- Rowing boat on the main deck.

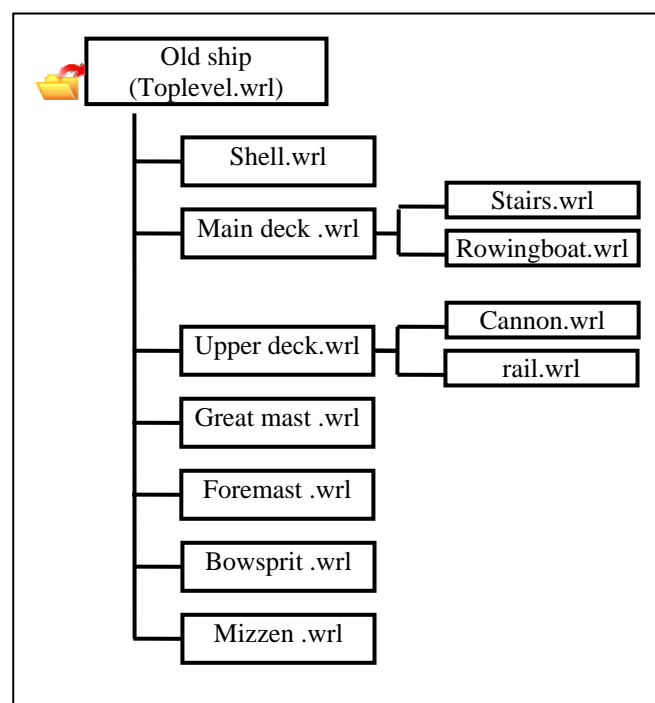


Figure 5: Example of hierarchical organisation

6. Three dimensions drawings

6.1 Colours, background and viewpoint [15]

For an efficient use of VRML, it is important to understand the basic management of colours. The colour is an object consists of a mix of the three primary colours: red, green, blue (R, G, B). The percentage of each primary colour is given by a number comprised between 0 and 1. Table 2 below show some usual colours. The colours is thus defined by a triplet of value R, G, B.

Color	Red	Green	Blue
silver	0.75	0.75	0.75
white	1	1	1
Dark blue	0	0	0.5
Grey	0.5	0.5	0.5
Yellow	1	1	0
Black	0	0	0
Brown	0.5	0	0

Table 2: Basic useful colours in VRML

In a VRML scenario, the background, (defined in the top level file) can be seen as a 3D sky dome above the object, as indicated in figure 4.

Background can be quite sophisticated. But, in most of the cases, one can define a shaded blue colour for a realistic the sky and one colour for the ground. An ambient light or directional light can be included to add light effects. At last, one or several viewpoints (like cameras) can be added to observe the scene.

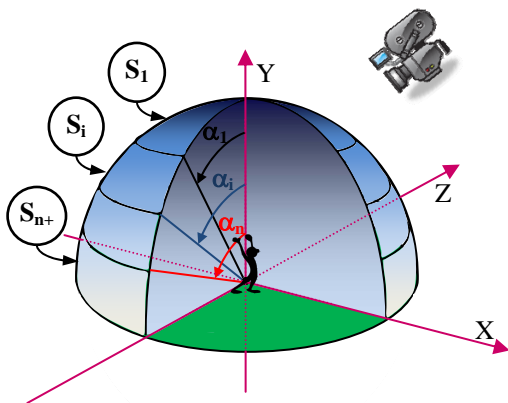


Figure 4: Background and viewpoint definition

6.2 Location of an object in 3D space

The location of a object in local or global reference axis system, is given as a triplet of values x, y, z:

$$translation\ 0\ 10\ 15$$

Orientation is set up as follow:

$$rotation\ x\ axis,\ y\ axis,\ z\ axis,\ angle\ \gg$$

For example:

$$rotation\ 0\ 1\ 0\ 1.57$$

means a rotation of 1.57 radians around y axis.

6.3 «Children » concept in VRML

A basic and interesting rudiment is the *children* concept. Indeed, an object can be described like a hierarchical family tree.

A unit « *child* » is defined by its properties and attributes shape, colour, transparency etc and has its “bias point” (i.e. its initial 3D location) as explained before. Then, a name is given to the child.

When objects are animated, the “child” may have its own individual movement (by programming evolution of its initial location), and at the same time be affected by the movement of the “parents”; Like a true child can move and play on the rear seat of a car, while the parent drives and the car moves forwards.

Therefore, we are able to understand the power of this programming to define complex movements.

6.4 Example of drawings

In this paragraph, we give some example of more or less complex drawings. This part of the creation work solicits mainly the right brain as said before.

6.4.1 Basics drawings

A wood house is shown in figure 5. The description is done using only the four basic shapes we presented before.



Figure 5: Canadian wood house

6.4.2 More complex drawings

The description of the airport shown in figure 6 is done using hierarchical structure. Because of the complex shape of the planes, they are drawn using a specific technique called “indexedFaceset” (and not using the four basic shapes). Oil truck, planes are described in sub files. Air control tower, tarmac are added at the top level file.

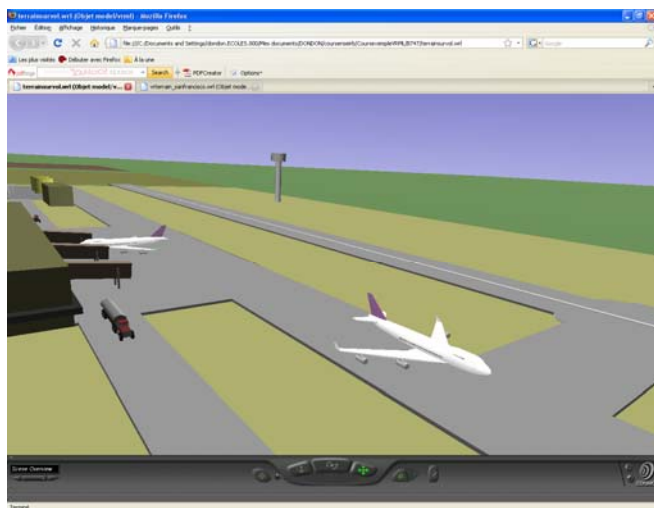


Figure 6: Airport

Other technique called “geometry Grid” is used to draw the landscape in figure 7. On the left side, we can distinguish the previously defined airport included as a sub file.

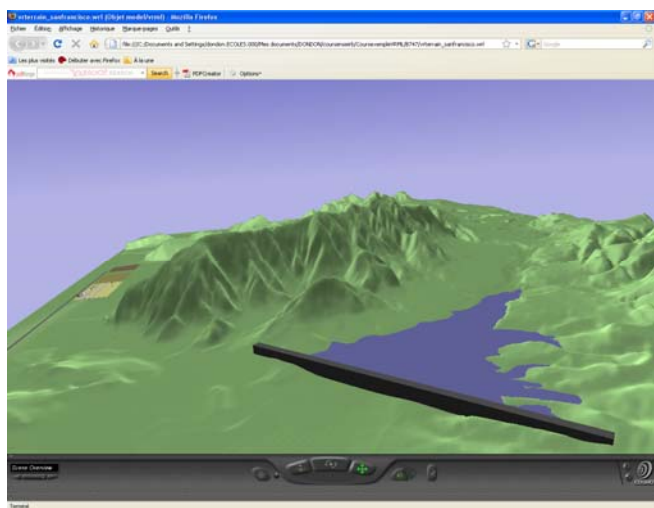


Figure 7: Mountain, lake and dam

7. Three dimensions animation modelling

Once the scene and various objects drawn, we can add animation and movements. This second part of the work solicits mainly the left brain.

7.1 Different ways to animate the drawings

Animating the objects means to define a trajectory. There two manner of describing trajectories [10]. By using the interpolator function or by writing the mathematical equations in a sub program Javascript. A particularity of VRML file is that is it not a sequential file: Several animations can be played in parallel (at the same time).

Whatever the way of description, one defines one or more animation cycle time with (or without) a loop to replay the animation permanently. The time base is given by the PC clock.

7.2 Adding interactivity

VRML allows adding interactivity with the users: live action on the played animation is possible thank to some “sensors”.

For example, one can change the colour, the location, the transparency of an object by a simple click with the mouse during the animation. Various effects (speed change, deformation...) can also be obtained thanks to javascript.

7.3 Interest of hierarchical structure for animation

Apart from the clarity and ease of programming, what is the interest of a hierarchical organization of files, especially with regard to the “Viewpoints” defined into a scene?

Consider the following example: a local viewpoint is defined in a sub *.wrl file. This file is included in a file of highest level. Thus, this local viewpoint becomes available in the list of views at the highest hierarchical level when the scene is displayed on a screen with the Cosmoplayer plug in:

You can therefore zoom (or move) on the details or the objects in the global scene, by simply clicking on the button “viewpoint” list.

Moreover, if one animates the object previously designed in this sub *.wrl, the viewpoint attached to this object and located inside this object is affected by the same movement:

Like a powerful embedded camera, one will follow the movement of object like in video game where one can be seated inside a race car or a plane (cf. the old and famous « Flight simulator »). The viewpoint can be

moved during animation from inside towards outside of the object to see it and to follow it at the same time.

7.4 Playing the animations

Once finished, the animated drawings can be displayed using Cosmoplayer plug-in for FireFox internet navigator or Orbisnap free viewer. Then, it can be converted in an *.AVI video clip with a freeware such as CAMSTUDIO, for portable demonstration or didactical uses or professional or personal WEB site enhancements.

8. Various didactical applications

Depending on the student’s level, VRML can have a wide range of applications. We give hereafter some progressive examples from simple to more complex.

8.1 Secondary school possible applications

8.1.1 Lower class

At the junior Secondary Education Certificate level, an interesting experience has been done in the French college “Simone Signoret” in Rouen (France) [15]. VRML was used for graphical arts course: primary colours mixing, sizing, scaling, proportion calculus and geometry basics. It was also an opportunity to sensitize pupils to the virtual world, and to become aware of all scientific knowledge and background required to design sophisticated video games.

8.1.2 Upper class

At the level of Preparation to Baccalaureate (or French high school diploma) in science stream, VRML can be used as complementary tools for illustration and visualization of:

- Mathematical basics concepts such as planar geometry, trigonometry, Cartesian axes of a direct orthonormed system, twist transformation matrix, and basic 2D curves,
- Physic basics such as Kinematics of solid, Newton’s laws, uniform movements in translation or rotation, collision, 1D, 2D trajectories etc.

We give hereafter three classical examples.

1° Example of cannonball trajectory:

Parabolic trajectory of a cannon ball calculation is a traditional work for teenagers. As a complement to the theoretical study, VRML can be an interesting way to program the movement laws and to display the results as indicated in figure 8.

Angle of inclination of the gun and initial speed of the ball are defined as parameters and can be changed to show their impacts on trajectory.

Length of the shot can be easily observed thank to the equally spaced white lines on the green floor.

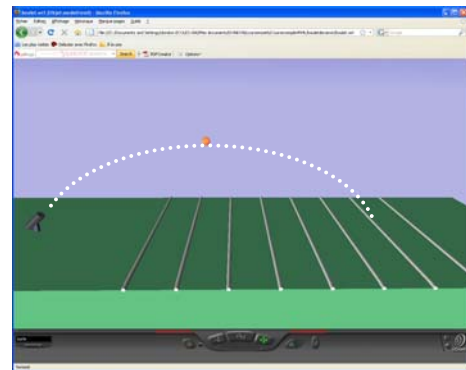


Figure 8: Cannonball shot (45°)

2° Example of elastic collision:

A second classical exercise illustrates the conservation of momentum and kinetic energy during an elastic collision between small discs without friction. In secondary school, this problem is usually studied in two steps:

- Theoretical equations,
- Practical demonstration with an air float table.

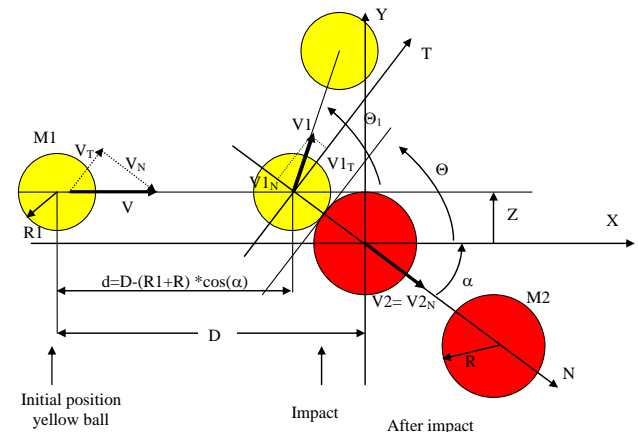


Figure 9: Geometrical aspects of collision

In order to complete such study, a last step can be added to merge theory and practice by using VRML. Figure 10 gives example of 3D VRML visualization and animation. Here movement are programmed in java script. Yellow disc is launched from left to right. After collision with the red disc initially motionless,

trajectories angles are changed according to kinetics laws. Diameter of the red discs and weight can be changed with the mouse cursors, to visualize interactively the consequences on speed and trajectories angles after the impact.

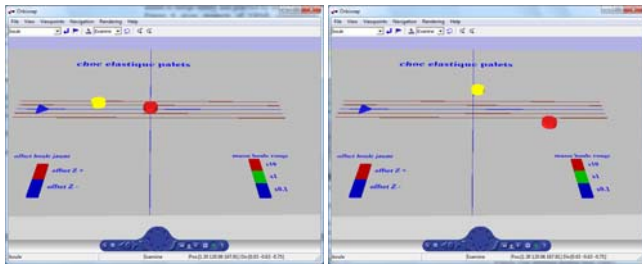


Figure 10: 3D VRML animated modelling; before and after discs collision

3° Example of rod piston movement modelling [16]:

Other traditional secondary school work is the study of rod piston movement. Movement of rod piston combines translation and rotation. A simple description of a piston in VRML is given with reference axis in figure 11a.

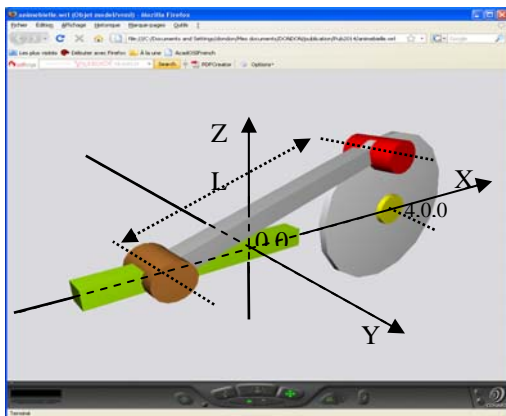


Figure 11a: Rod piston modelling

One more time, VRML appears like a supplementary didactical and useful tool to merge theoretical aspects and concrete 3D visualisation of the movement.

For a more complete exercise, the rod piston can be then included as sub VRML files to describe the movement of a “old” steam engine. The VRML modelling is inspired from the fully functional Wileco D22 small scale didactical steam engine (replica of mill engine of early 1900’s in British science museum). [17]. (cf. figure 11b and 11c)

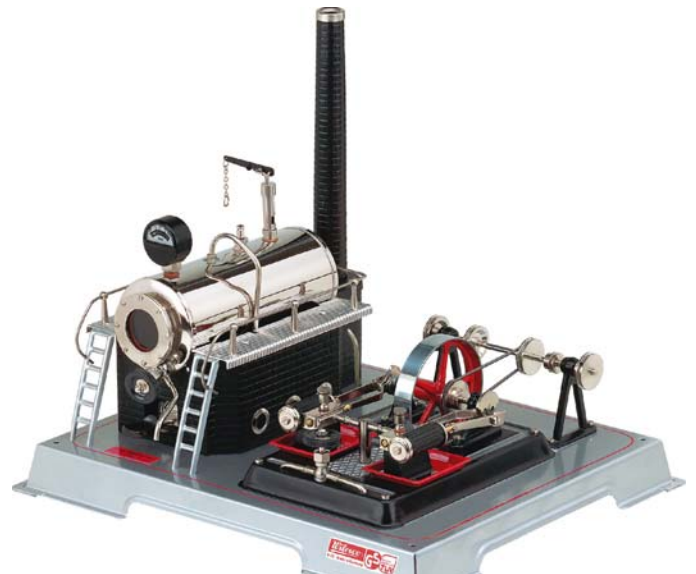


Figure 11b: Steam engine with double effect twinned cylinder, flywheel, water tank, boiler pressure gauge, chimney (Wileco company)

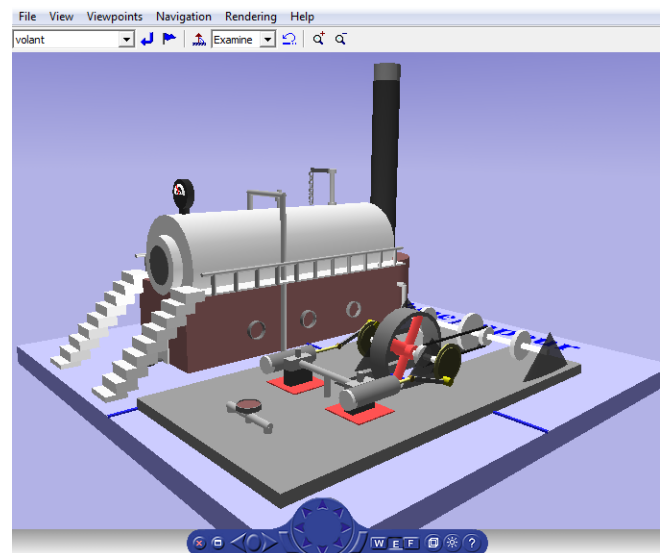


Figure 11c: VRML modelling of a steam engine with double effect twinned rod piston

8.2 Possible uses for undergraduate and post graduate students

Many applications can be implemented for university students. VRML can be used for 3D modelling of complex process in various fields of study (For example electronic, automatic, mechanics, chemical, biology). Particularly, in our main field of work, Interface with MATLAB or SPICE is a powerful ability of VRML to display simulation results in another way than classical 2D curves.

It is also an opportunity to remind and to develop some 3D descriptive geometry basics like surfaces intersections, and 3D trajectory equations.

We give hereafter some ideas of applications.

8.2.1 Stirling engine modelling and animation

A first example is given in figure 12a and 12b. Within the framework of practical lessons on energy generation and saving at Enseirb-Matmeca school, a Stirling engine [18] [19] is available for some practical measurements and demonstration.

A VRML modelling has been built to represent the coupled mechanical movements of the two pistons when the main tube is heated by an alcohol lamp flame.

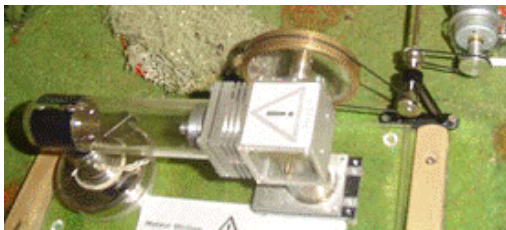


Figure 12a: Stirling engine (top view)

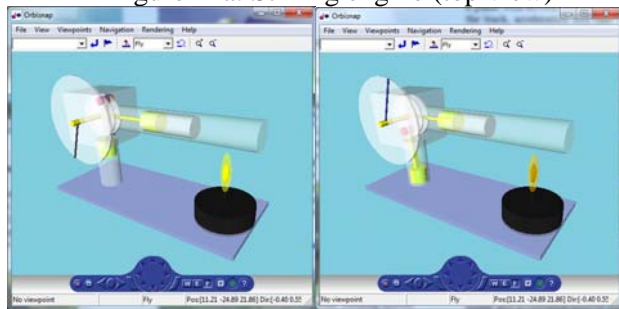


Figure 12b: VRML animated modelling of Stirling engine

8.2.2 Solar panel tracking modelling [20] and animation

A simplified full analogue small scale solar tracking system (based on hobbyist servomotor, LDR light sensors and PWM classical LM555 circuits) has been designed during an Enseirb-Matmeca student's electronic project (Cf. figure 13a).



Figure 13a: Small scale solar tracking system

This system has been first fully modelled and validated with SPICE simulator.

Then, to get a realistic view of the tracking movement and feed back loop efficiency, a 3D VRML modelling has been realised by transferring data from SPICE simulation files to a VRML animated file (Cf. figure 13b).

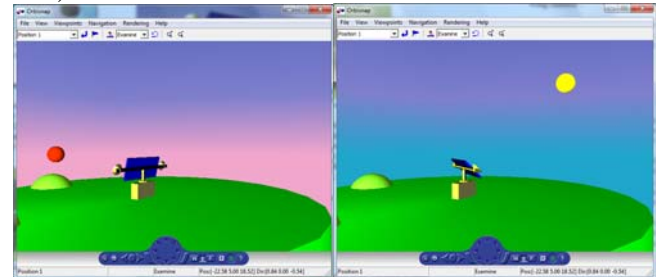


Figure 13b: VRML modelling of solar tracking system (Sunset and midday view)

8.2.3 Modelling “take off” of a plane

In § 6.4.2, drawing of an airport was briefly described. An interesting work can be to program a “take off” of a plane with several phases, rolling from terminal to the track, acceleration and take off, ascent etc. (Cf. figure 14).

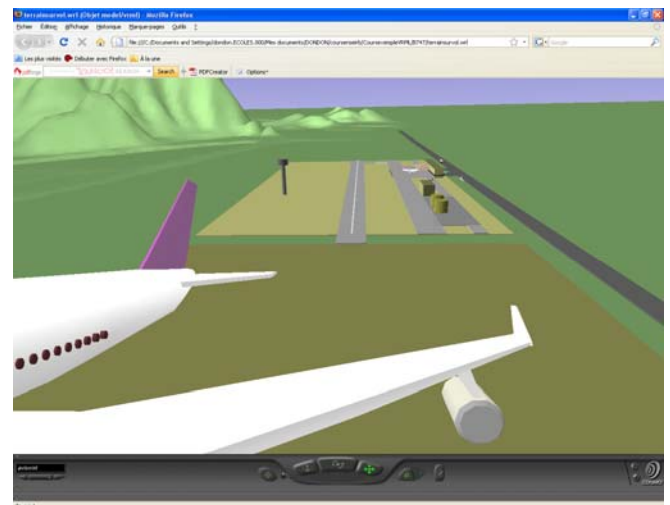


Figure 14: Plane “take off” viewed from “embedded wing camera”.

As the trajectory is defined by several segments, the mathematical continuity between each, in position, speed, and acceleration must be managed to generate a fluid and realistic movement.

9. Discussion and comments

9.1 Scientific assessment

After a self training period to learn VRML, it took several hundred hours to create and experiment all the examples (a few thousand written VRML lines for each example) given in this paper and to adapt them to the student's profiles and level.

It was an interesting exploration and excellent sensitizing to virtual world for those who are not specialists of this scientific field. In particular, transposing and comparing electronic circuit design with VRML design helped to understand some "esoteric" concepts.

Discovering SPICE simulator/VRML interface gives opportunity for electronic specialist to valorise the simulation results differently and more lively than classical 2D curves.

9.2 Didactical assessments

Till now, a 50 pages course material, including all examples described in this paper, has been created and inserted as WEB page into the didactical WEB site of the authors [9].

As VRML do not belong to the main fields of studies of the electronic department, we chose to put this work first in open access. It is available for all students of the Enseirb-Matmeca school, and others.

We hope to test the student's reaction and interest with small group of volunteers very soon. Depending on the results, we will decide some extensions, modifications or adaptations.

At the end of this present work and compared to other VRML experiences [21], [22], [25], [26] we are now fully convinced of the interest of VRML in term of creativity improvement, artistic sense development, mental concentration training, logical reasoning and mathematical solicitation.

9.3 Future work

More than pure didactical applications, all this preliminary training will be also applied to future research work in "electronic for sustainable development" at Enseirb-Matmeca engineer school; these works will be published in the near future.

10. Conclusion

An exploration of VRML world and an overview of didactical applications were presented in this paper. Psychological impact and technical aspects have been highlighted thanks to a global approach. Advantages and inconvenient have been emphasized and discussed. In particular, despite its old age, VRML remains an excellent brainstorming free tool for

training students as well as senior (exactly like we can do with mathematical games, brain teaser, Sudoku, and all the games who contribute to mental exercises, memory training and concentration stimulation). Finally, several concrete handmade examples were described. Ideas of didactical training and applications have been given while possible extension of this work has been suggested.

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