June 2021
version : 1.0

3D VISUALIZE SOFTWARE: ELECTROMAGNETIC WAVE

USER MANUAL

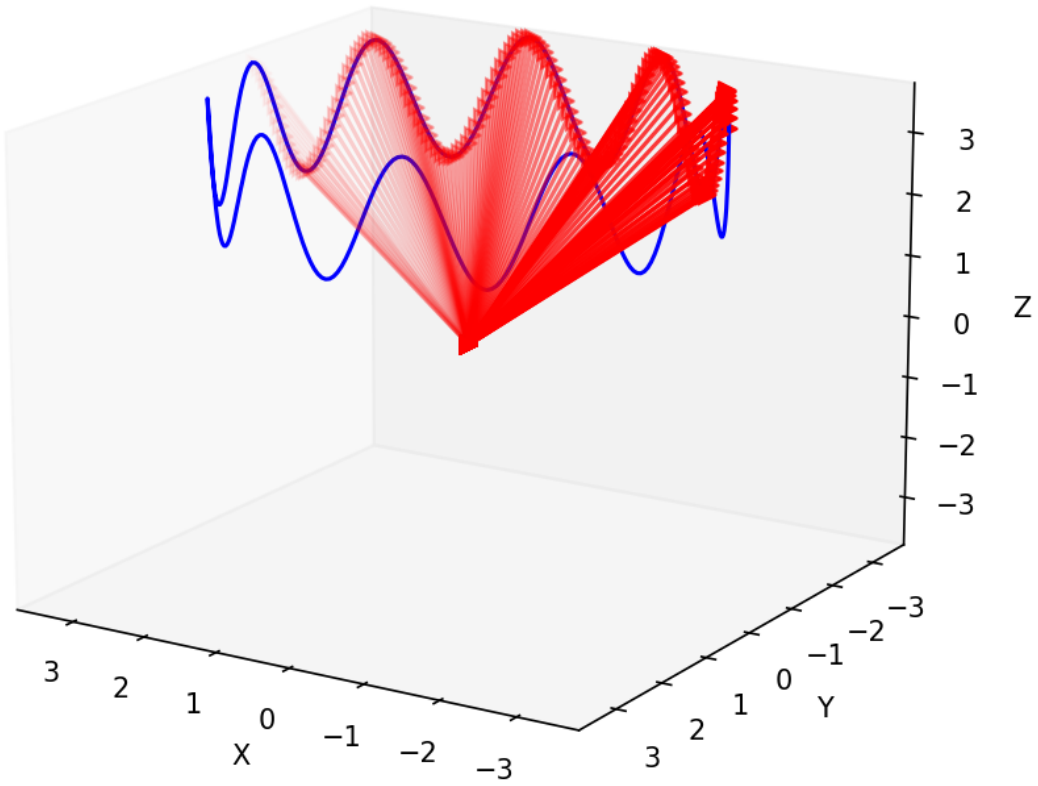

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TABLE DES MATIERES

How to install it?

Requirements

Software required

This program run with **Python 3.9.5**, previous or later version may not run properly.
https://www.python.org/downloads/release/python-395/

Python modules required

Module name	**Version required** *(Previous or later version may not run properly)*	**Website**
Matplotlib	3.4.2	*https://matplotlib.org/*
NumPy	1.20	*https://numpy.org/*
PyQt5	5.15.2	*https://www.riverbankcomputing.com/software/pyqt/*

Command line in your interactive Python prompt, to check and download missing modules:
pip install matplotlib NumPy pyqt5

Optional

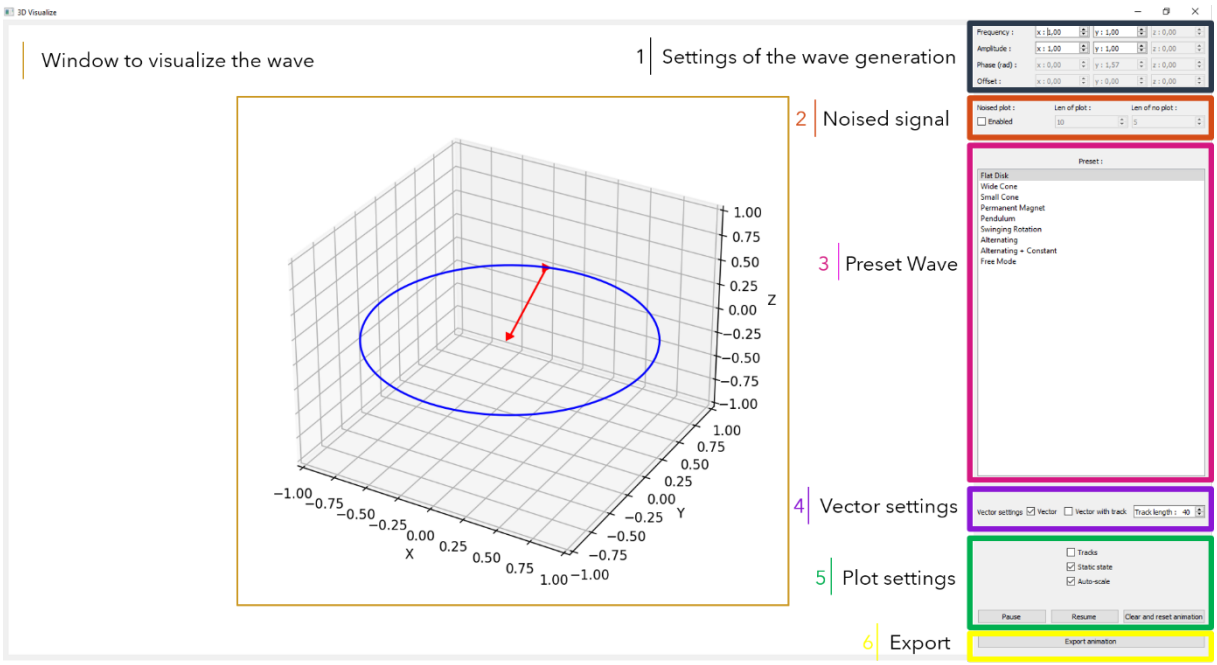
Software

To export figure to gif or mp4, program requires **ImageMagickDisplay** encoder.
https://imagemagick.org/script/download.php

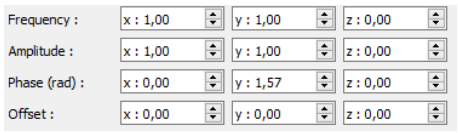
To launch and modify Python program more easily, for instance Pyzo IDE could be used. However, all IDE could be used.
https://pyzo.org/

GENERAL PRESENTATION

MAIN WINDOW



1. SETTINGS OF THE WAVE GENERATION



The wave is generated after this system of equation:

$$\begin{cases} B_x = A_x \cos(2\pi f_x t + \phi_x) + K_x \\ B_y = A_y \cos(2\pi f_y t + \phi_y) + K_y \\ B_z = A_z \cos(2\pi f_z t + \phi_z) + K_z \end{cases}$$

User has the choice among 4 parameters, set for each axis:

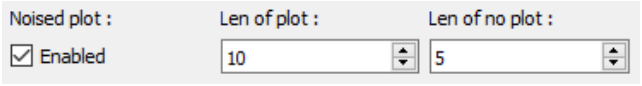
A: Amplitude

f: Frequency

ϕ : Phase (in rad)

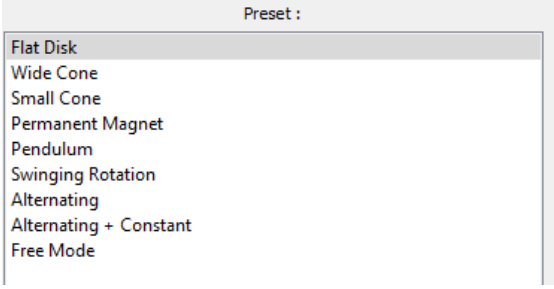
K : Offset

1. FRAGMENTED SIGNAL



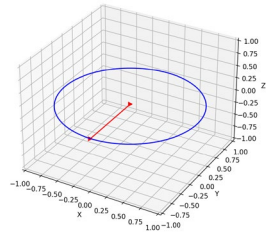
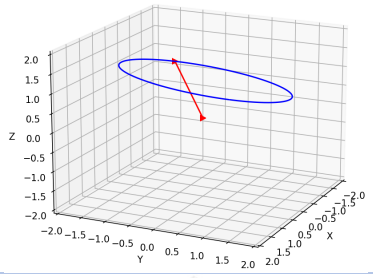
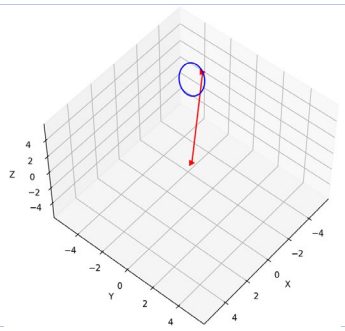
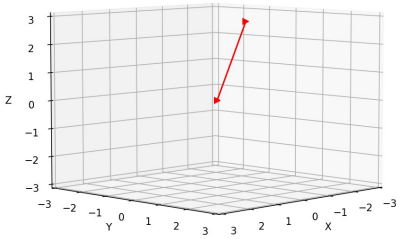
Generate a wave with “gap” to represent discrete behavior of the wave.

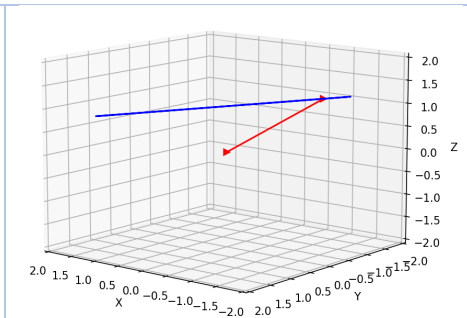
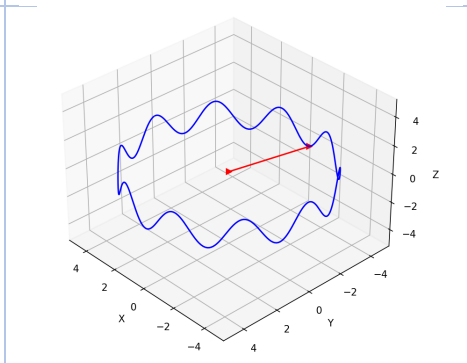
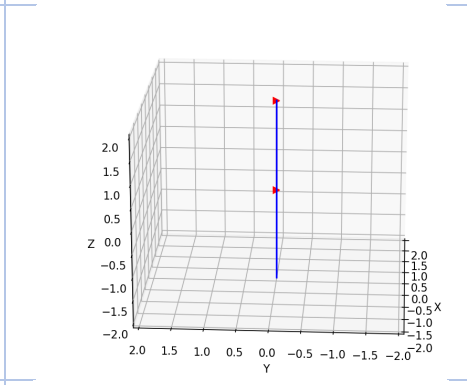
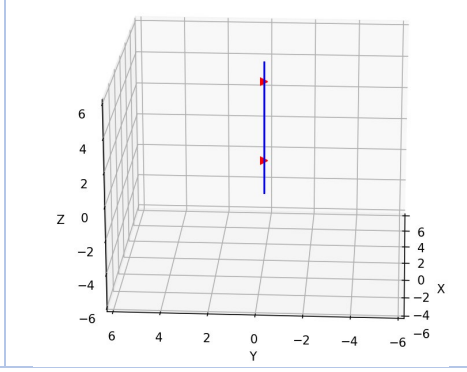
2. PRESET GENERATION



For more convenience, preset for the wave are already implemented.

Rules and shape visualization are defined in the table below:

	Shape	Frequency (f_x,f_x,f_z)	Amplitude (A_x,A_y,A_z)	Phase (ϕ_x,ϕ_y,ϕ_z)	Offset (K_x,K_y,K_z)
Flat disk		f_x,f_x,0	A_x,A_x,0	0, $\frac{\pi}{2}$,0	0,0,0
wide cone		f_x,f_x,0	A_x,A_y,A_z	0, ϕ_y,0	0,0,0
Small cone		f_x,f_x,0	A,A,A_z where A_z>>A	0, ϕ_y,0	0,0,0
Permanent magnet		0,0,0	A_x,A_y,A_z	ϕ_x,ϕ_y,ϕ_z	0,0,0

Pendulum		$f_x,f_x,0$	A_x,A_y,A_z	ϕ_x,ϕ_y,ϕ_z	0,0,0
Swinging rotation		f_x,f_x,f_z où $f_z>>f$	A,A,A_z où $A_z<A$	$0,\frac{\pi}{2},0$	0,0,0
Alternating		0,0,f_z	0,0,A_z	0,0,0	0,0,0
Alternanting + constant		0,0,f_z	0,0,A_z	0,0,0	K_x,K_y,K_z

When selecting a shape, default values for the different parameters are applied. However, these default values are always adjustable, while keeping the rules described by the shape. The spinboxes of the set values are grayed out and the dependent values continue to be set according to the rules mentioned in the table.

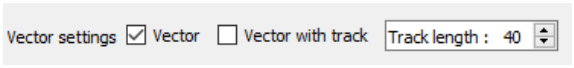
Example:

For the 'Wide cone', the change of frequency is only possible on x (the frequency on y is directly updated). The amplitudes remain independent, and only the phase along y can be modified.

Free Mode:
Allow to change all parameters independently of each other, with the aim to custom the figure.

Tip:
Move from a preset shape to free mode, doesn't change settings and keep last shape. It's a good way to custom a preset shape.

3. VECTOR SETTINGS

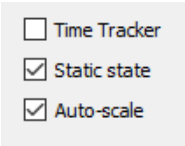


Displays a vector when "Vector" is selected. A vector plots an arrow between the point (0,0,0) to ($B_x(t)$, $B_y(t)$, $B_z(t)$).

"Vector with track" displays the trace of the vector, with a linear decreasing opacity. The length of the trace is the number of vectors to keep in the window.

Plot a too many vectors involve a slowdown of the animation. If you encounter this problem, even after decreased the track length, the only solution is to restart the program.

4. PLOT SETTINGS



A. TIME TRACKER

When enabled, allows to follow the plot in time, frame by frame.

Note: you must disable static state to see it

B. STATIC STATE

Option activated by default; it allows to see the whole wave.

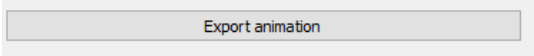
C. AUTO-SCALE

Auto scale (enabled by default), will scale x,y,z, with the maximum among the amplitudes of each coordinate. Allow to see the wave with any distortion due to perspective
Disable it, allow to move around the wave during the animation. Otherwise, pause is required.

D. PAUSE/RESUME/CLEAR & RESET ANIMATION

Pause the plot and the animation, like vector track. When the animation is paused, you can move around the wave.
Resume: resume animation.
Clear & reset animation: Clear all plot in the figure, and restart time to 0.

5. EXPORT BUTTON



Export a complete sequence using the software " ImageMagick Display " which must be installed on the computer (cf. *How install it?*).

Two types of formats are authorized, gif and mp4. To select format, change the extension of the file in the save dialogue.

Note: mp4 format is more compressed than gif format, involving mp4 file taking less storage than gif.

The export is long and can give the impression that the program has crashed, you must be patient (several minutes are required).

ADVANCED CUSTOMIZATION

Many options can be changed directly in the code of the program. These options are stored in a dictionary; thus, the syntax is 'name of the option': value or string assigned.

ANIMPARAMETERS

In this dictionary, all parameters related to the animation are here.

Name of the option	Description	Default value
nPoint	Number of points to plot the wave.	360
interval	Time between 2 frames in ms.	30
repeat	When animation is finished, i.e. all points are plotted, the animation is stopped. Warning: when animation is stopped, impossible to restart it in the user interface	True
Repeat_delay	Time between two animations	0
nVector	Len length at initialization for the vector track	1
fragmentedNoPlotLen	Len of gap between 2 segments for the noised signal	5
fragmentedPlotLen	Len of the plot for one segment for the noised signal	10
Fps	Frame per second for the record video	60
Writer	Software to encode the animation.	'imagemagick'

STATE

Boolean variable of different state of options for the plot are store here. This dictionary is updated in the program with user interface. However, set value here allow to enable or disable option when the program start.

Name of the option	Description	Default value
Vector	Display the vector (only one)	True
timeTrack	Enable time tracker	False
vectorTrack	Enable track of vector	False
Static	Display the whole wave	True
autoscale	Manage auto-scale	True
Fragmented	Generate a fragemented signal	False

PRESETPARAMETERS

List of preset, with 'name of the preset' : [fx,fy,fz,Ax,Ay,Az,Phix,Phiy,Phiz,offsetx,offsety,offsetz].
In the same logic than the table of rule in the section "preset generation" , you can create your own rules or modify existing.

WARNING: You need to fill or modify wavePresetValue if you add or modify a rule.

WAVEPRESETVALUE

List of default values related at a preset. Its structure is "Name of the preset" :[first value variable,..,last values variable]. You need enter a value only for the first variable if there are variables connected, and you must not set a value for constants. None allow to not set a value, it will be the last value set which will use.

****** Enjoy! ******

General Functioning for an Advanced usage

The program is based with the animation module of matplotlib, more precisely with FuncAnimation function[1]. This animation has an update function called at each frame; all parameters of this function are available in the *animParameter* dictionary. This update function launches different plot in function of types of plots enabled. All states are embedded in the state dictionary, updated at each interaction with the checkbox. Besides, plot need value to plot, and this part is managed by the *Bgen* function, relying with *B* function, a generation of cosine function with all parameters described in the Settings of the wave generation section. Therefore, *Bgen* is totally generated before to be plotting, the reason is to optimize the number of computes, and allow to move between all types of plots without change value or restart the plot. *Bgen* function can cut the array when *fragmented* state is enabled, allowing generation of an array with gap. *Bgen* change the attribute *Barray* of *MplCanvas* object. Exportation is also handled by animation module, when record is called, a save dialog is opened, and the path is registered, the repeat of the animation is paused to save only one sequence, a new sequence is created, then the path is given in *save* method of *animation* module.

The second main part of the program is the user interface, powered by PyQt5. Like in the *general presentation* section, the program divides interface in 8 parts. *ParametersBox* object (sub-class of *QDoubleSpinBox*) to set value of each wave parameters, stored in the *waveParameters* dictionary. When value in spinbox changed, plots are cleared, a new *Barray* is generated, a new sequence of image is created thanks the method *func_clear* in *MplCanvas* object.
States are controlled by *CheckBoxCustom* (sub-class of *QCheckBox*), when a box is check or uncheck state takes the opposite, and search the case thanks the state name. All states have different methods launch in the *stateSwitch* method.

1. https://matplotlib.org/stable/api/_as_gen/matplotlib.animation.FuncAnimation.html#matplotlib.animation.FuncAnimation

Improvement for the program

The possible features improvement is the control of the time, have a correspondence between time and frame. Currently, in cause of a slowdown we can't define an interval time too small.
Currently, frequency represents only the number of turns to plot the number of points. Therefore, a too high frequency could not represent the good shape.
One solution may be plotting a surface starting by the first vector and with a decreasing opacity, to replace all vectors.