A MATLAB BASED VECTGUI SIMULATION TOOL

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Abstract:

The vector analysis graphical user interface (VECTGUI), a MATLAB-based vector analysis visualization tool, can be used as a supplementary tool in the first course of electromagnetic education. The main purpose of this tool is to provide various visual aids that assist students in developing a mental image of some fundamental concepts in vector calculus and curvilinear coordinate systems. This tool is composed of seven sub-tools: two designed for the dynamic visualization of geometries in cylindrical and spherical coordinates, two used to display the scalar and vector fields and three designed to demonstrate the gradient, curl and divergence fields.

Keywords: MATLAB, Vector Graphical User Interface, electromagnetic, education, visualization, seven sub-tools.

Introduction:

Vision plays a vital role in electromagnetics because it removes the obstacle in understanding and perception of physical phenomena. New students often think that electromagnetics is a difficult course because some mathematical and geometrical concepts, as well as electromagnetic fields that are vector functions of space and time, are abstract and hard to visualize. Therefore, a well-established background on vector calculus and coordinate systems is essential in developing a better understanding of electromagnetic phenomena. VECTGUI is an easy-to-use 3D vector field simulator with a friendly GUI. It can visualize the vector field, calculate divergence and also plot the curl of the field, all in one single GUI. VECTGUI is an upgraded GUI version of function VECTLINE (Vector Field Line Plotter). Depending on the dimension of coordinate axis, vectline can plot both 2D and 3D vector field line.

Literature Survey:

A vector-based graphical user interface is a mostly conceptual type of graphical user interface where elements are drawn using vector rather than raster information. The vector based interface is better than raster based interface because it is more efficient and has independent scalability.

Tools:

MATLAB is known as a Matrix Laboratory where it acts as a calculation software and high performance numerical analysis. It has a unique advantage in dynamic system simulation, numerical computing, signal processing and in other areas. MATLAB and GUI are used to visualize EM fields of electromagnetic waves that are obtained by solving Maxwell's equations. This method is used to solve the problem of resultant EM fields which is the combination of electric and magnetic fields where it is complicated to visualize and understand. Teaching electromagnetics using novel modelling and simulation approach has been discussed. Virtual tools for teaching advanced-level mathematical functions and tools have been reviewed with useful package.Scalar and vector fields plays a major role in electromagnetics. To describe the variations of scalar and vector quantities in space, a suitable coordinate system is needed. Although the laws of electromagnetism are valid in any coordinate system, a coordinate system provides a frame of reference and is chosen based on the symmetry of the geometry to ease its analysis. Therefore, the vector analysis has three main ingredients: 1) an orthogonal coordinate system (Cartesian, cylindrical and spherical); 2) vector algebra; and 3) vector calculus. Among them, the curvilinear coordinate systems and the concepts of gradient, divergence and curl which are based on the del differential operator are sometimes hard to visualize.

VECTGUI Package:

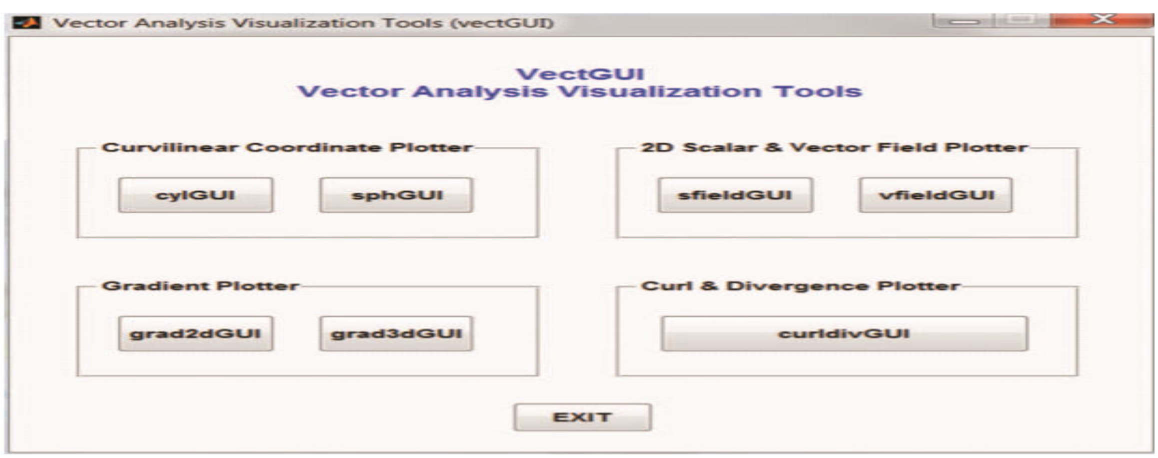

Fig 1: The main window of the VectGUI Package

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VECTGUI is a MATLAB-based tool for visualizing some fundamental concepts in vector analysis. The main window of this package is shown in fig. 1. The package includes seven sub-tools. The cylGUI and sphGUI plot geometries in a dynamic manner by varying one of the coordinate variables in cylindrical and spherical coordinates respectively. The cylGUI tool in fig. 2 is designed to display geometries in a cylindrical coordinate system. The user enters the ranges of each coordinates (r, phi, z). Once one of the plot buttons is clicked, the corresponding variable is sampled by a number of samples between the lower and upper limits, and the geometry is dynamically formed by drawing constant surfaces at every 0.1 s. The sphGUI tool in fig. 3 is designed to display geometries in a spherical coordinate system by varying one of the coordinate variables (R, theta, phi). This is similar to cylGUI tool.

The sfieldGUI tool in fig. 4 is designed to display the contour and surface plots of a scalar field in a 2-D Cartesian system. The function is symbolically entered by the user. The ranges of the function and the number of points along the x and y axes are also provided by the user. The vfieldGUI tool in fig.5 is designed to plot a vector field in a 2-D Cartesian system. The scalar components of the vector field are entered symbolically by the user.

The grad2dGUI tool in fig. 6 is designed to plot the gradient field of a scalar field in a 2-D Cartesian system. The field itself might also be plotted. The scalar field is symbolically entered by the user, together with its ranges. The components of gradient vector are also displayed symbolically. The grad3dGUI tool in fig 7 is designed to plot the gradient field of a scalar field in a 3-D Cartesian system. This is similar to grad2dGUI tool.

The curldivGUI tool in fig. 8 is designed to plot the divergence and curl of a vector field in a 2-D or 3-D Cartesian system. The components of the vector field are entered symbolically by the user. The expressions for curl and divergence are also displayed symbolically. The description of all the seven sub-tools is shown in table 2.

Result:

TABLE 2. THE SUBTOOLS OF THE VECTGUI PACKAGE.

Tool Name	Description
cylGUI	Displays geometries in a cylindrical coordinate system by changing one of the coordinate variables in a dynamic manner.
sphGUI	Displays geometries in a spherical coordinate system by changing one of the coordinate variables in a dynamic manner.
sfieldGUI	Displays a user-defined scalar field in 2-D.
vfieldGUI	Displays a user-defined vector field in 2-D.
grad2dGUI	Displays a scalar field and its gradient field in 2-D.
grad3dGUI	Displays a scalar field and its gradient field in 3-D.
curldivGUI	Displays a vector field and its curl and divergence fields in 2-D and 3-D.

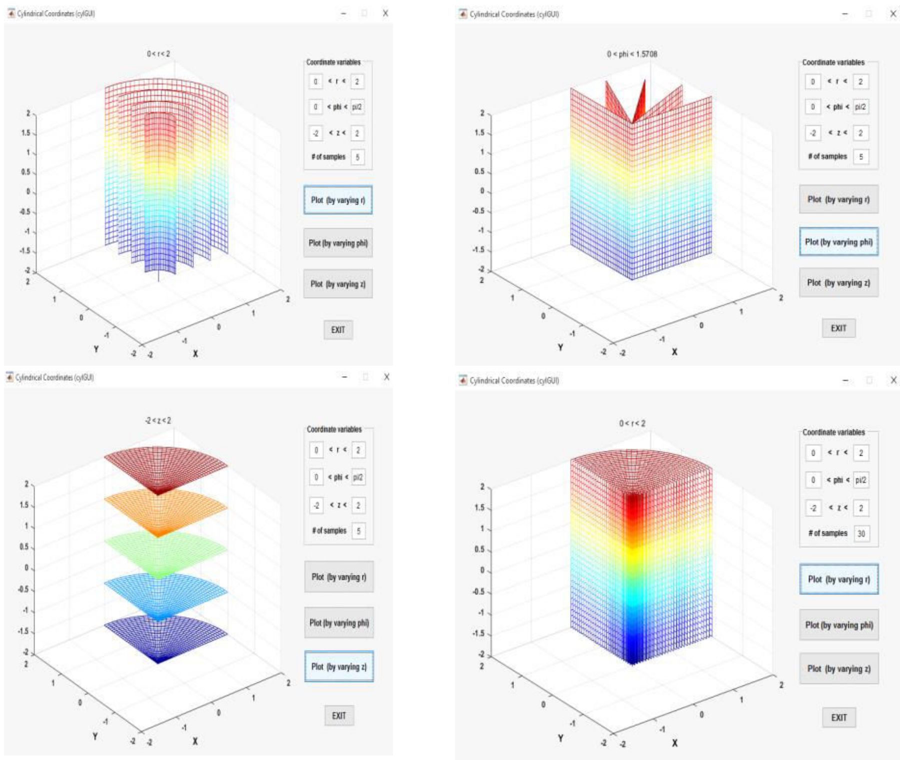
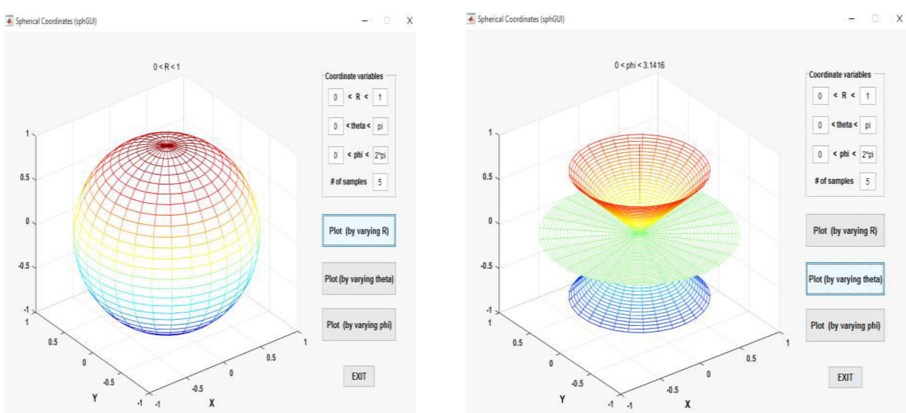


Fig 2: The cylGUI Window: (a)the r-constant surfaces, (b)the pi-constant surfaces, (c)the z-constant surfaces and (d)the formed geometry



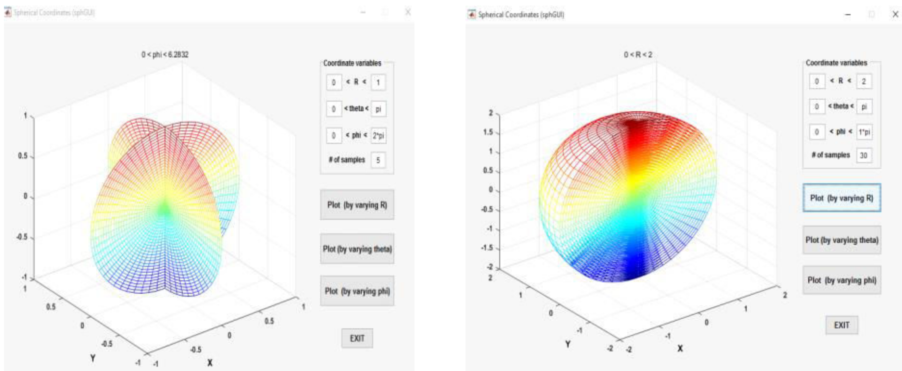


Fig3: The sphGUI window: (a) the R-constant surfaces, (b) the theta-constant surfaces, (c) the pi-constant surfaces and (d) the formed geometry.

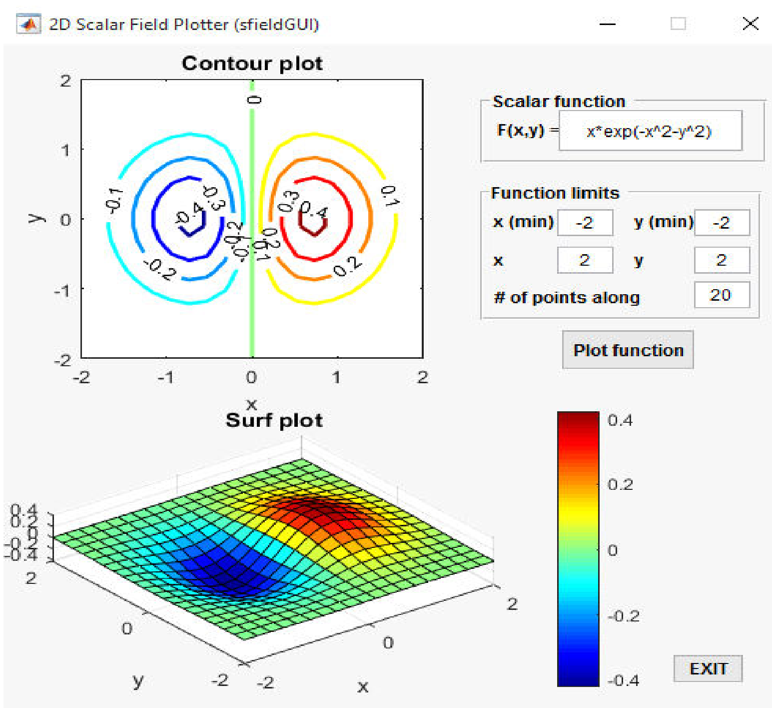


Fig 4: The sfieldGUI window

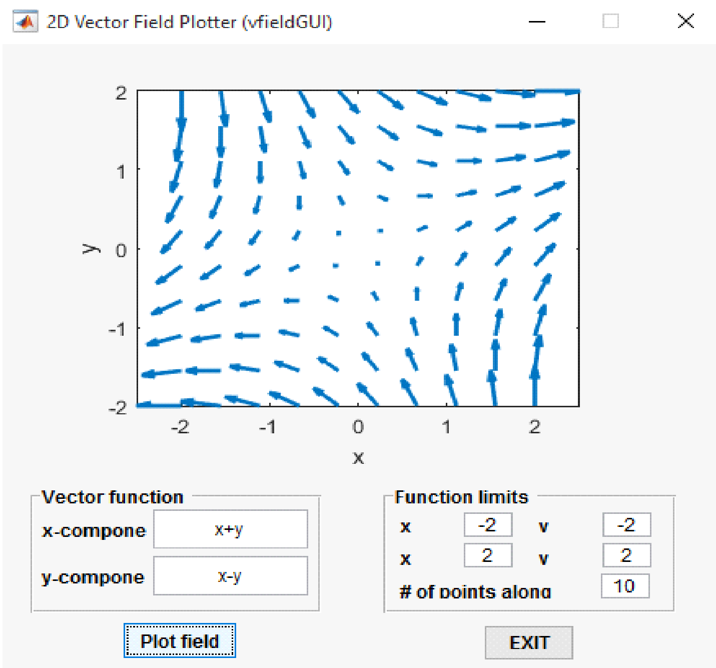


Fig 5: The vfieldGUI window

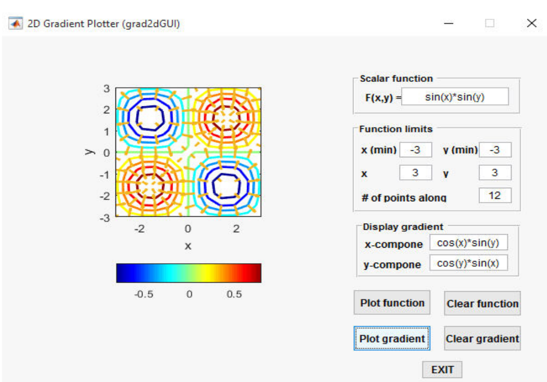


Fig 6: The grad2DGUI window

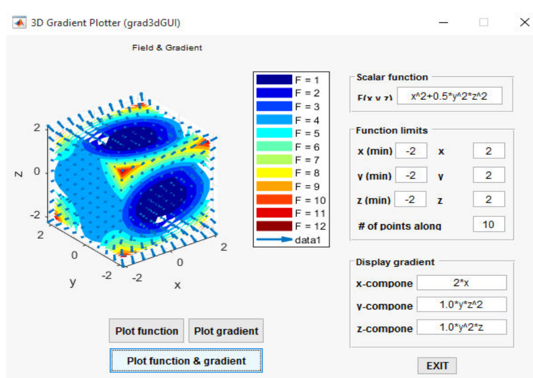


Fig 7: The grad3DGUI window

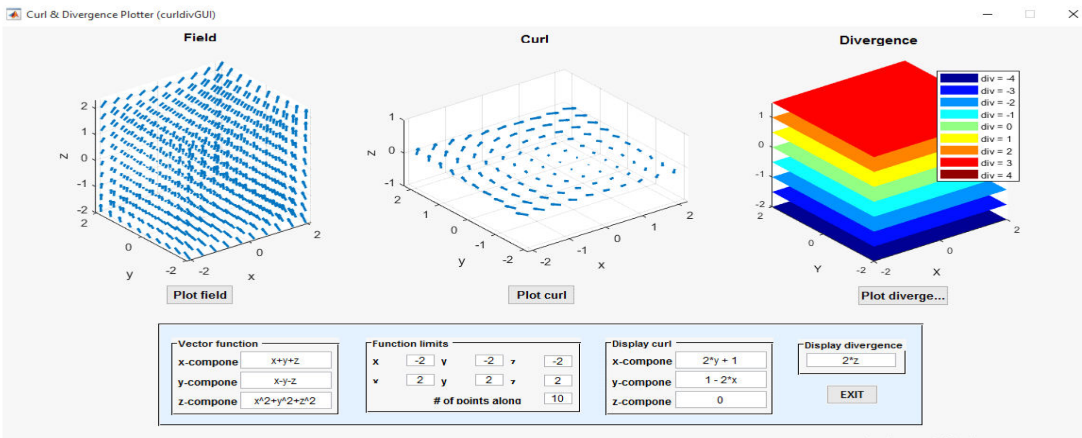


Fig 8: The curldivGUI window

Conclusions:

The intent of the MATLAB-based VECTGUI simulation tool is to develop a better conceptual understanding of curvilinear coordinate systems, scalar and vector fields, gradient, curl and divergence. The tool may be used in undergraduate electromagnetics courses and in other disciplines that use vector analysis.

References:

[1] https://ieeexplore.ieee.org/document/7214374

[2] https://en.m.wikipedia.org/wiki/vector-based_graphical_user_interface

[3] L. Sevgi, “Teaching electromagnetic modeling and simulation as a graduate-level course,” IEEE Antennas. Mag., vol. 54, no. 5, pp. 261-269, Oct. 2012.

[4] L. Sevgi, “A new electromagnetic engineering program and teaching via virtual tools,” Progr.Electromagn. Res. B (EWS 2006 Special Issue), vol. 6, pp. 205-224, 2008.

[5] L. Sevgi, Complex Electromagnetics problems and Numerical Simulation Approches. Hoboken, NJ: IEEE Press- John Wiley, 2003.

[6] https://www.semanticscholar.org/paper/VectGUI%3A-A-MATLAB-Based-simulation-Tool-[Testing-Ozgun-Sevgi/542b458f2194938ce6e380cfae8155403e896384

[7] G. Torogulu and L. Sevgi, "FDTD MATLAB codes for the first and second electromagnetic models," IEEE Antennas Propogat. Mag., vol. 56, no. 2, pp. 221-239, Apr. 2014.