Rendering of Antenna 3D Beam Pattern Geometry using 4NEC2 Output File

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Introduction : 4NEC2 Program

- NEC2 is ..
 - Common program to analyze antenna beam pattern.
 - Programed in FORTRAN, therefore it is not familiar and difficult to use.
- 4NEC2
 - Arie Voors encapsulates NEC2 code with windows-based GUI and provides good environment to use NEC2 code.
 - 4NEC2 program is easy to use.

Anec2 🎇 By Arie Voors	🞇 Main [V5.8.16] (F2)	- 🗆 X
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Introduction : 4NEC2 Output File

- Input/output files are ascii text files and easy to read.
- 4NEC2 is good for a beginner of Antenna beam pattern to understand.

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Introduction : Generated X3D Files

- X3D files are generated using our program from output file.
 - Commonly familiar 3D scene
 - We can control composition and color as we want.
 - We are now searching a way to give more information, intuitively.



Table of Contents : Conversion Procedure to Generate X3D File

- In this presentation
 - The conversion procedure to generate X3D file from 4NEC2 output file.
 - The 4NEC2 output format and NEC2toX3D.m code are introduced briefly.



4NEC2 Program

- NEC-2 based antenna modeler and optimizer
 - (NEC-2 Fortran Code) + (GUI), By Arie Voors
 - You can get this program free. (ver 5.8.16)
 - http://www.qsl.net/4nec2/
- NEC (Numerical Electromagnetics Code)
 - Popular antenna modeling system for wire and surface antennas
 - It was originally written in FORTRAN in the 1970s by Gerald Burke and Andrew Poggio of the Lawrence Livermore National Laboratory
 - By far the most common version is **NEC-2**, the last to be released in fully public form
 - <u>https://en.wikipedia.org/wiki/Numerical_Electromagnetics_Code</u>

Input of 4NEC2

• .NEC file has Geometry information of Antenna

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Run 4NEC2.exe (1/3)

- Menu \rightarrow File \rightarrow Open 4nec2 in/out files \rightarrow Open
 - .nec samples are in folder of 4nec2/models/

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Run 4NEC2.exe (2/3)

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Run 4NEC2.exe (3/3)

- Menu \rightarrow Edit \rightarrow Output (.out) file
 - .out results are in folder of 4nec2/out/

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Output of 4NEC2

- .out file has
 - Geometry information of the antenna
 - Radiation patterns of the antenna
 - **Power gains** (vertical/horizontal/total)
 - Electric field magnitude (theta/phi)
- .out files are
 - Located at folder of 4nec2/out/

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ANO THETA DEGREES -90.00 -85.00 -80.00 -75.00 -70.00 -65.00	GLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7 36	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.22	R AXIAL RATIO 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	ADIATION POLARIZAT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MGGNITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50772E-01 3.16807E-01 3.16807E-01 3.92982E-01 4.14382E-01	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87	MAGNIT VOLTS 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	E(PHI) UDE 5/M 1E+00 1E+00 1E+00 1E+00 1E+00 1E+00)
ANC THETA DEGREES -90.00 -85.00 -80.00 -75.00 -70.00 -65.00 -60.00 -55.00	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00	VERT. DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31	R AXIAL RATIO 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	ADIATION POLARIZAT TILT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	PATTERNS - SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MAGNITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50772E-01 2.22605E-01 3.16807E-01 3.16807E-01 3.1118E-01	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73	MAGNIT VOLTS 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	E(PHI) UDE /M E+00 E+00 E+00 E+00 E+00 E+00 E+00 E+0)
ANC THETA DEGREES -90.00 -85.00 -75.00 -75.00 -65.00 -65.00 -55.00 -50.00	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04	R. AXIAL RATIO 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	ADIATION POLARIZAT TILT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	PATTERNS - SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MAGNITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50772E-01 2.22605E-01 3.16807E-01 3.16807E-01 3.71118E-01 3.04320E-01	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83	MAGNIT VOLTS 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	E(PHI) UDE 5/M 1E+00 1E+00 1E+00 1E+00 1E+00 1E+00 1E+00 1E+00 1E+00 1E+00)
ANC THETA DEGREES -90.00 -85.00 -75.00 -75.00 -60.00 -55.00 -55.00 -20.00	GLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.36 -8.31 -10.04 2.57	POWER G/ HOR. 	AINS - TOTAL DB -999,99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57	AXIAL RATIO 0.00600 0.00600 0.00600 0.00600 0.00600 0.00600 0.00600 0.00600 0.00600 0.00600	ADIATION POLARIZAT: TILT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	ION SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MAGNITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50777E-01 2.22605E-01 3.16807E-01 3.02982E-01 3.71118E-01 3.04320E-01 1.29914E+00	ETA) PHASE DEGRES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31	MAGNIT VOLTS 0.000000	E(PHI) UDE 5/M E+00 E+00 E+00 E+00 E+00 E+00 E+00 E+0)
ANCO THETA DEGREES -90.00 -85.00 -85.00 -75.00 -75.00 -65.00 -60.00 -55.00 -50.00 -20.00 -15.00	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.82 -7.36 -8.31 -10.04 2.57 3.26	POWER G/ HOR. _999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999,99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 -2.57	R AXIAL RATIO 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	ADIATION POLARIZAT TILT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MAGHITUDE VOLT5/M 7.81629E-12 9.54471E-02 1.56977E-01 3.16807E-01 3.02982E-01 3.02982E-01 3.04320E-01 3.04320E-01 1.29914E+00 1.40701E+00	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31 142.53 140.31	MAGNIT VOLTS 0.000000	E(PHI) UDE 5/M FE+00 FE+)
ANC THETA DEGREES -90.00 -85.00 -75.00 -65.00 -65.00 -50.00 -55.00 -15.00 -15.00 -15.00 -59.00	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. D8 -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91	R AXIAL RATIO 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	ADIATION POLATIAT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	PATTERNS - JON SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MAGNITUDE VOLT5/M 7.81629E-12 9.54471E-02 1.50772E-01 3.06807E-01 3.02982E-01 3.02982E-01 3.04320E-01 3.04320E-01 1.29914E+00 1.40701E+00 1.47713E+00 1.5183E+00	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31 142.53 143.99 144.84	MAGNIT VOLTS 0.000000	E(PHI) UDE /M E+00 E+00 E+00 E+00 E+00 E+00 E+00 E+0	
ANC THETA DEGREES -90.00 -85.00 -75.00 -65.00 -65.00 -55.00 -55.00 -20.00 -15.00 -10.00 -5.00	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.266 3.68 3.91 3.98	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91 3.98	R AXIAL RATIO 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000 0.09000	ADIATION POLARIZAT TILT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	PATTERNS - ION SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR	E(TH MAGNITUDE VOLT5/M 7.81629E-12 9.54471E-02 1.50772E-01 3.16807E-01 3.16807E-01 3.92982E-01 3.71118E-01 3.71118E-01 3.71118E-01 3.04320E-01 1.29914E+00 1.47713E+00 1.47713E+00 1.51851E+00	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31 142.53 143.99 144.84 145.11	MAGNIT VOLTS 0.000000	E(PHI) UDE J/M E+00 E+00 E+00 E+00 E+00 E+00 E+00 E+0))
ANC THETA DEGREES -90.00 -88.00 -75.00 -75.00 -76.00 -60.00 -50.00 -50.00 -10.00 -15.00 -10.00 -5.00 0.00 -20.00 -15.00 0.00 -20.000 -20.000 -20.000 -20.000 -20.000 -20.00000 -20.00000 -20.00000 -20.00000 -20.00000 -20.0000000 -20.00000 -20.0000000 -20.000000000	5LES PHI DEGREES 0.00	VERT. D8 -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91 3.98 AIN= 1.553	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999,99 -20.11 -16.14 -12.75 -9.69 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91 3.98 SOL	R AXIAL RATIO 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	ADIATION POLARIZAT TILT DEG. 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	ATTERNS - SENSE SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR ALINEAR AGGING-(2)	E(TH MAGNITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50772E-01 3.16807E-01 3.02982E-01 4.14282E-01 3.71118E-01 3.04320E-01 1.29914E+00 1.47713E+00 1.51583E+00 1.52811E+00	ETA) PHASE DEGREES 58.16 -110.33 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31 142.53 143.99 144.84 145.11 RADIANS.	MAGNIT VOLTS 0.00006 0.0006 0.00006 0.00006 0.00006 0.00006 0.00006 0.00006 0.00	E(PHI) UDE /M iE+00 iE+01 iE+0)
ANC DEGREES -90.00 -85.00 -75.00 -75.00 -65.00 -65.00 -55.00 -55.00 -55.00 -55.00 -55.00 0-55.00 0-55.00 0-5.00 -5.	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. 999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91 3.98 AIN= 1.5533	POWER G/ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91 3.98 50L	R AXIAL RATIO 0.000000	ADIATION I POLARIZAT, TILT DEG. 0.0000 0.0000 0.0000 0.000000	PATTERNS - SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR RAGING=(2	E(TH MAGMITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.56977E-01 3.16807E-01 3.02932E-01 4.14282E-01 3.04320E-01 1.29914E+00 1.40701E+00 1.515935+00 1.52811E+00	ETA) PHASE DEGREES 58.16 -110.33 -85.759 -37.94 -24.32 -11.87 4.73 34.83 140.31 142.53 143.99 144.84 145.11 RADIANS.	MAGNIT VOLTS 0.0000E 0.000E	E(PHI) UDE /M iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+00 iE+01 iE-11 iE-11 iE-11)
ANK THETA DEGREES -90.00 -85.00 -85.00 -75.00 -75.00 -50.00 -20.00 -15.00 -15.00 -15.00 -50.00 -	SLES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. 999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.91 3.98 AIN= 1.5533	POWER GJ HOR. DB -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.68 3.91 3.98 SOL:	R AXIAL RATIO 0.000000	ADIATION I POLARIZAT TILT DEG. 0.0000 0.0000 0.0000 0.000000	PATTERNS - SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR RAGING=(2	E(TH MAGMITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50772E-01 3.16807E-01 3.02932E-01 4.14282E-01 3.04320E-01 3.04320E-01 1.40701E+00 1.40701E+00 1.51533E+00 1.52811E+00	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31 142.53 143.99 144.84 145.11 RADIANS.	MAGNIT VOLTS 0.00006 0.0006 0.00006 0.00006 0.00006 0.00006 0.00006 0.0	E(PHI) UDE E+000 E+00) [
ANO THETA DEGREES -90.00 -85.00 -75.00 -75.00 -50.00 -50.00 -20.00 -15.00 -15.00 -15.00 -15.00 -20.00 -3.00 -20.00 -5.00 -20	ELES PHI DEGREES 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	VERT. 999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.91 3.98 AIN= 1.5533 0. 8 EN	POWER GJ HOR. -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99 -999.99	AINS - TOTAL DB -999.99 -20.11 -16.14 -12.75 -9.69 -7.82 -7.82 -7.36 -8.31 -10.04 2.57 3.26 3.91 3.98 SOL:	R AXIAL RATIO 0.000000	ADIATION I POLARIZAT TILT DEG. 0.0000 0.000000	PATTERNS - SENSE LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR LINEAR RAGING=(2	E(TH MAGNITUDE VOLTS/M 7.81629E-12 9.54471E-02 1.50772E-01 3.16807E-01 3.02902E-01 4.14282E-01 3.02902E-01 4.14282E-01 3.04320E-01 1.29914E+00 1.40701E+00 1.51583E+00 1.52811E+00	ETA) PHASE DEGREES 58.16 -110.33 -85.37 -57.59 -37.94 -24.32 -11.87 4.73 34.83 140.31 140.31 142.53 143.99 144.84 145.11 RADIANS.	MAGNIT VOLTS 0.00006 0.0006 0	E(PHI) //M IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+00 IE+01 IE-11 IE-11 IE-11 IE-11) D

Run NEC2toX3D.m

- Launch MATLAB → NEC2toX3D(filename, scale)
 - filename : Output file name of 4NEC2
 - scale : scale of antenna geometry
- .x3d file is generated at same folder.

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Final Output X3D file

- X3D Scene has
 - Antenna Shape Geometry
 - Antenna 3D Beam Pattern (Antenna Total Gain) Geometry
 - Color Map Index





Excerpts from NEC2toX3D.m (1/3)

- Part 1 Antenna Shape Geometry
 - Line 5~29 : Read from 4NEC2 output file
 - Line 183~204 : Write down as LineSet using X3D grammar

4					
5	\$	-			
6	\$ \$ \$	=	182		-
7	\$ \$ \$ \$		183	%%%% Write Down Antenna Shape	L
8	% Jump file pointer to Antenna Geometric Array		184 -	[nElement temp] = size(antennaWire);	4
9	<pre>% Find word ' WIRE'</pre>	-	185		L
10	% and Get next of next line	_	186 -	<pre>fprintf(pf X3D.'\n <!-- Antenna Geometry Part--> \n');</pre>	L
11 -	tline = ' ';	-	187 -	fprintf(pf X3D.' <transform %d="" %d''="" scale=""> \n'.scale antenna, scale antenna</transform>	L
12 -	<pre>while ~((tline(3)=='W') && (tline(4)=='I') && (tline(5)=='R') && (tline(6)=='E'))</pre>		188 -	<pre>fprintf(pf X3D,' <shape> \n');</shape></pre>	L
13 -	<pre>tline = fgetl(fid);</pre>	-	189 -	<pre>fprintf(pf X3D.' <appearance> \n');</appearance></pre>	1
14 -	<pre>if (max(size(tline)) < 6) tline = ' '; end</pre>		190 -	<pre>fprintf(pf X3D.' <material 0.7="" 0.7''="" emissivecolor=""></material> \n');</pre>	L
15 -	end		191 -	<pre>fprintf(pf X3D,' \n');</pre>	L
16 -	<pre>tline = fgetl(fid);</pre>		192 -	<pre>fprintf(pf X3D,' <lineset ');<="" pre="" vertexcount=""></lineset></pre>	L
17 -	<pre>tline = fgetl(fid);</pre>		193 -	for i = 1:nElement	L
18	<pre>%disp(tline);</pre>	_	194 -	<pre>fprintf(pf X3D,'2 ');</pre>	L
19	<pre>% Extract Antenna Geometry Array [xl yl zl x2 y2 z2 :]</pre>	-	195 -	- end	L
20 -	<pre>numberOfWire = 0;</pre>		196 -	<pre>fprintf(pf X3D,'''>\n');</pre>	L
21 -	while (max(size(tline)) > 100)		197 -	<pre>fprintf(pf X3D,' <coordinate ');<="" point="" pre=""></coordinate></pre>	L
22 -	<pre>numberOfWire = numberOfWire + 1;</pre>		198 -	for i = 1:nElement	L
23 -	antennaWireTemp(numberOfWire,:) = sscanf(tline,'%f',[1 12]);		199 -	<pre>fprintf(pf X3D,'%f %f %f %f %f %f ', antennaWire(i,1), antennaWire(i,2), antenna'</pre>	L
24 -	<pre>tline = fgetl(fid);</pre>		200 -	- end	L
25 -	end		201 -	<pre>fprintf(pf X3D,'''/>\n');</pre>	-
26 -	numberOfWire		202 -	<pre>fprintf(pf_X3D,' \n');</pre>	1
27 -	<pre>antennaWire = antennaWireTemp(l:numberOfWire, 2:7);</pre>		203 -	<pre>fprintf(pf X3D,' \n');</pre>	
28	<pre>%antennaWire</pre>		204 -	<pre>fprintf(pf_X3D,' \n');</pre>	
29 -	clear antennaWireTemp		205		1
30		_			_

Excerpts from NEC2toX3D.m (2/3)

end

- Part 2 Antenna 3D Beam Pattern Geometry
 - Line 33~57 : Read from 4NEC2 output file

 Line 206~210, 318~360 : Write down as IndexedFaceSet using X3D grammar

33		%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	-				
34		\$ \$ \$ \$					
35		8888					
36		% Jump file pointer to Antenna Pattern Array	-				
37		% Find word ' DEG'					
38		% and Get next line					
39	-	tline = ' ';					
40	-	while ~((tline(2)=='D') && (tline(3)=='E') && (tline(4)=='G'))					
41	-	<pre>tline = fgetl(fid);</pre>					
42	-	<pre>if (max(size(tline)) < 4) tline = ' '; end</pre>					
43	-	- end					
44	-	<pre>tline = fgetl(fid);</pre>					
45		<pre>%disp(tline);</pre>					
46		% Extract Antenna Pattern Array [THETA PHI TOTALDB:]					
47	-	numberOfPattern = 0;					
48	-	while (max(size(tline)) > 2)					
49	-	<pre>numberOfPattern = numberOfPattern + 1;</pre>					
50	-	<pre>antennaPatternTemp(numberOfPattern,:) = sscanf(tline,'%f',[1 5]);</pre>					
51	-	<pre>tline = fgetl(fid);</pre>					
52	-	- end					
53	-	<pre>antennaPattern = antennaPatternTemp(l:numberOfPattern, 1:2);</pre>	-				
54	-	antennaPattern(l:numberOfPattern,3) = antennaPatternTemp(l:numberOfPattern, 5);	-				
55	-	numberOfPattern					
56		<pre>%antennaPattern</pre>					
57	-	clear antennaPatternTemp					

[function HandleSurface(obj handle)		^	
-	global pf_X3D;			
-	<pre>info.coord = 'surfCoord';</pre>			Ξ
-	<pre>info.coordIndex = 'surfCoordIndex';</pre>			
-	<pre>info.color = 'surfColor';</pre>			
-	<pre>info.colorIndex = 'surfColorIndex';</pre>			-
-	<pre>obj = get(obj_handle);</pre>			
-	<pre>handle_str = sprintf('%s%g',deblank(obj.Type),double(obj_handle));</pre>			
-	handle_str = abs(handle_str);			
-	<pre>h = find(handle_str == '.');</pre>			
-	$handle_str(h) = []; $ $\pm ok$			=
-	<pre>handle_str = char(handle_str);</pre>			
-	<pre>if(strcmp(obj.Visible, 'on'))</pre>			
	% Handle FaceColor mode			
-	<pre>if ~strcmp(obj.FaceColor, 'none')</pre>			-
-	<pre>fprintf(pf_X3D,' <shape>\n');</shape></pre>			
-	<pre>fprintf(pf_X3D,' <indexedfaceset ');<="" pre=""></indexedfaceset></pre>			
-	if ~ischar(obj.FaceColor)			
-	$\underline{i} = 0;$			
-	else			
-	switch obj.FaceColor			
-	case 'flat'			
-	<pre>colorIndex(obj,info.colorIndex,'flat');</pre>			
-	case 'interp'			
-	colorIndex(obj,info.colorIndex,'interp');			
-	case 'texturemap'			
-	otherwise			_
-	error('Unknown FaceColor type in Handle Patch');			-
-	end			
-	end			
-	coordindex(obj,info.coordindex);			
-	<pre>sendStr(24, 'solid=''false''> \n');</pre>			
-	coord(ob),info.coord);			
_	<pre>facecolor(obj,info.color.obj.FaceColor);</pre>			
-	<pre>fprintf(pf X3D,' \n');</pre>			
-	<pre>fprintf(pf X3D,' \n');</pre>			
-	end			

Excerpts from NEC2toX3D.m (3/3)

• Part 3 - Color Map Index

• Line 218~292 : Write down using HUD Prototype

218	%%%% Colormap			
219 -	<pre>fprintf(pf_X3D,'\n</pre>	HUD : Colormap Part \n');	=	
220 -	fprintf(pf_X3D,'	Simple Heads-Up Display (HUD) Prototype\n \n Manages the display of a HUD an</p	=	
221 -	fprintf(pf_X3D,'	<pre><externprotodeclare (hud)="" aligned<="" appinfo="" child="" display="" geometry="" heads-up="" keeps="" pre=""></externprotodeclare></pre>	_	
222 -	fprintf(pf_X3D,'	<field 'inputoutput"="" 'outputonly''="" accesstype="'inputOutput" appinfo="'HUD orientation update relative to o</td><td>_</td></tr><tr><th>226 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td></ExternProtoDeclare> \n');</td><td>_</td></tr><tr><th>227 -</th><td>fprintf(pf_X3D,'</td><td><ProtoInstance DEF=''HeadsUpDisplayInstance'' name=''HeadsUpDisplay''> \n');</td><td>-</td></tr><tr><th>228 -</th><td>fprintf(pf_X3D,'</td><td><! example: upper left-hand corner of screen (x=-2, y=1) and set back z=-5 fr</td><td>_</td></tr><tr><th>229 -</th><th><pre>fprintf(pf_X3D,'</pre></th><th><fieldValue name=''screenOffset'' value=''0 0 -5''/> \n');</th><th>-</th></tr><tr><th>230 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><fieldValue name=''children''> \n');</td><td></td></tr><tr><th>231 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Transform translation=''1.9 0 0''> \n');</td><td></td></tr><tr><th>232 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Shape> \n');</td><td></td></tr><tr><th>233 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Box size=''0.2 3 0.01'' solid=''false''/> \n');</td><td>_</td></tr><tr><th>234 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Appearance> \n');</td><td></td></tr><tr><th>235 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><PixelTexture image=''1 33 3 0x000081 0x0000A1 0x0000C1 0x0000E1 0x0002</td><td></td></tr><tr><th>236 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td></Appearance> \n');</td><td></td></tr><tr><th>237 -</th><th><pre>fprintf(pf_X3D,'</pre></th><th></Shape> \n');</th><th></th></tr><tr><th>238 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td></Transform> \n');</td><td></td></tr><tr><th>239 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Transform translation=''1.78 0 0''> \n');</td><td></td></tr><tr><th>240 -</th><td>fprintf(pf_X3D,'</td><td><Transform translation=''0 1.7 0''> \n');</td><td></td></tr><tr><th>241 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Shape> \n');</td><td></td></tr><tr><th>242 -</th><td><pre>fprintf(pf_X3D,'</pre></td><td><Text string=''" dbi"''=""> \n');</field>		
243 -	<pre>fprintf(pf_X3D,'</pre>	<fontstyle "end"="" "middle"''="" <="" colormaptickfont''="" def="" justify="" pre="" size="</td><td></td></tr><tr><th>244 -</th><td><pre>fprintf(pf_X3D,"></fontstyle>	\n');	

Antenna 3D Beam Patterns (1/2)

- Case of existence of ground
 - Reflection should be considered in beam pattern.
 - How about existence of sea or water?



<Nec3ElementYagi20mAt50ft.x3d>

<NecSpiderQuad.x3d>

<NecHelix.x3d>

Antenna 3D Beam Pattern (2/2)

- In the case of free space, maximum magnitude of total antenna gain (in dBi) means the effectiveness of antenna.
- We like this layout, because it is easy to understand which antenna is more effective.





<NecParabola50x50.x3d>







<NecBowtieXg91a.x3d>

Axis

- For Antenna 3D Beam Pattern
 - Axis : Log scale
 - Unit : dBi (Antenna Gain)
- For Antenna Shape Geometry
 - Axis : Linear
 - Unit : meter (Length)

Suggested visualization (1/2)

- Beam Propagation : Z axis, logarithmic scales
- Fixed color map : For easy comparison



Suggested visualization (2/2)

- Beam Propagation : Z axis, logarithmic scales •
- Fixed color map : For easy comparison •













<NecBowtieXg91a.x3d>

Questions

- Any suggestions and questions are helpful to us.
- Please reply any comments to <u>skwon@nps.edu</u> or Brutzman@nps.edu.

Appendix

- 3D Visualization of Beam Pattern of MATLAB -

FEB 9 2018 – FEB 13 2018

Radiation Pattern

- 3D antenna directivity (in decibels)
 - ant = yagiUda; Freq = 300e6;
 - pattern(ant, freq);



Individual Polarization Components

- Directivity of the azimuthal(H) component of E field
 - Ant = yagiUda; Freq = 300e6;
 - pattern(ant, freq, 'Polarization', 'H');



Electric Field and Power

- Normalized magnitude of the E field
 - Ant = yagiUda; Freq = 300e6;
 - pattern(ant, freq, 'Type', 'efield', 'Normalize', true);



Antenna Radiation Patterns Examples

https://www.mathworks.com/help/antenna/gs/_mw_10718407-83ff-44e5-96c5-ff5f768f0e67.html



Blake chart (1/2)

- range-angle-height plot for a narrowband radar antenna
 - the maximum radar range as a function of target elevation



Blake chart (2/2)

CRPL Exponential Reference Atmosphere Model

The blakechart function uses the CRPL Exponential Reference Atmosphere to model refraction effects. The index of refraction is a function of height

$$n(h) = 1.0 + (N_s \times 10^{-6})e^{-R_{exp}h}$$

where N_s is the atmospheric refractivity value (in units of 10^{-6}) at the surface of the earth, R_{exp} is a decay constant, and h is the height above the surface in kilometers. The default value of N_s is 313 and can be modified using the 'SurfaceRefractivity' Name-Value pair. The default value of R_{exp} is 0.143859 and can be modified using the 'RefractionExponent' Name-Value pair.

References

[1] Blake, L.V. Machine Plotting of Radar Vertical-Plane Coverage Diagrams. Naval Research Laboratory Report 7098, 1970.