MagnetoBot User Manual

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To Start Immediately: Run MagnetoBot.m

Downloading the Software and Formatting Data

To run MagnetoBot and associated MagGridBot, you have MATLAB (equipped with nlinfit) working in MagnetoBot's Directory. You can download the software from GitHub, and you might have already done so. Once installed, move into the MATLAB folder of your computer. Then, place a .mat, .csv, or .txt file with the following formats into the same folder as MagnetoBot. If you have 2D gridded data, place your .txt file (also using the format below) into the folder labeled "MagGridBot." Running MagGridBot will allow you to choose a linear magnetic profile from 2D text files, and automatically save them as usable .mat files in MagnetoBot's directory with the filename "MagGridBot_Out".

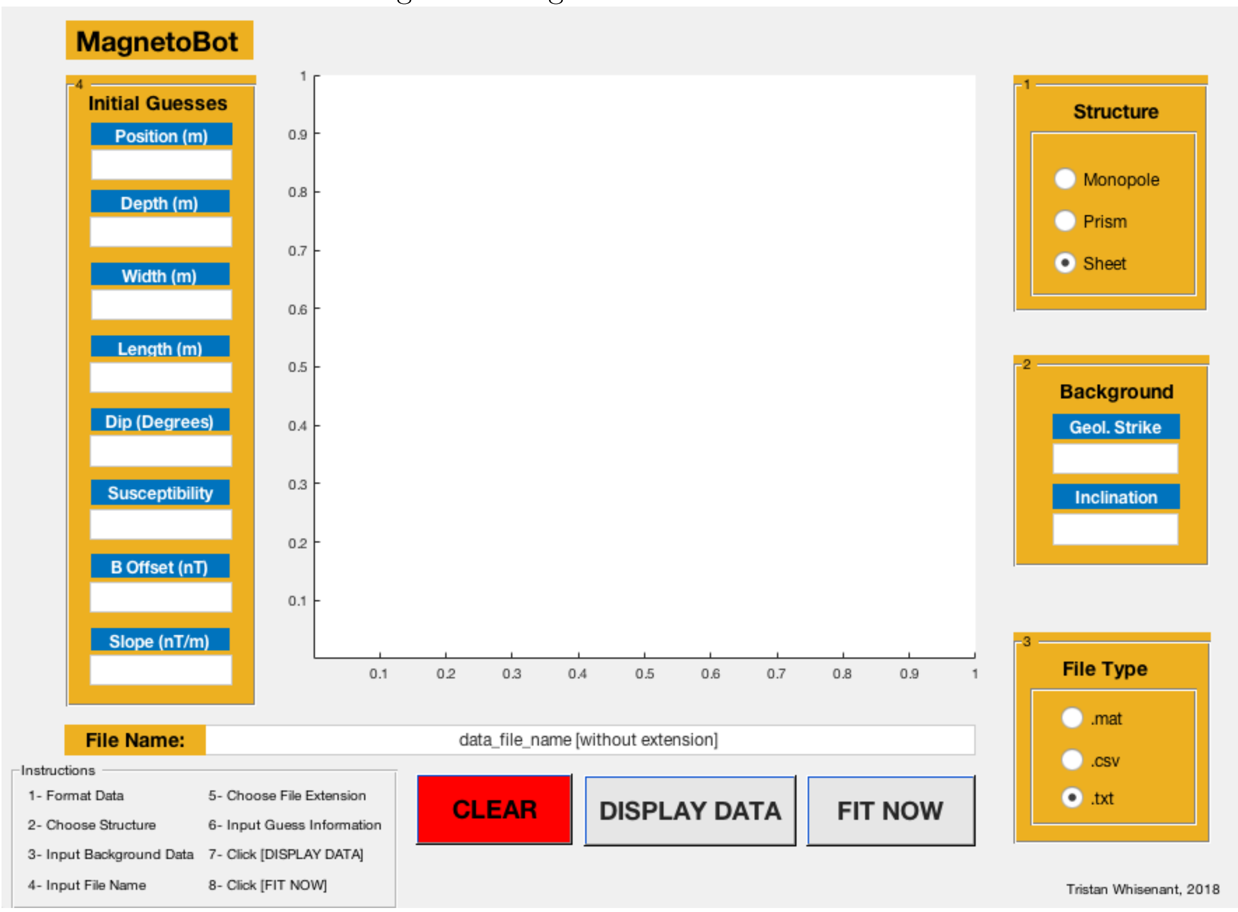
Acceptable Data Formats

.mat Files (Recommended): These files must contain three, nx1 column vectors with the variable names: LATITUDE, LONGITUDE, and MAGNETIC
.csv Files: These files must be unheaded, comma separated values with the format: LATITUDE,LONGITUDE,MAGNETIC
.txt Files: These files must be unheaded, tab separated values with the format: LATITUDE LONGITUDE MAGNETIC

* NOTE: Older versions of MATLAB may require the .txt/.csv extension to be included.

After this step, the rest is (relatively) straightforward. *I have included some test files in the download to play around with before having to craft your own (see TESTDATA1, TESTDATA2, ...).

Figure 1: MagnetoBot at first launch.



Plotting the First Data Set

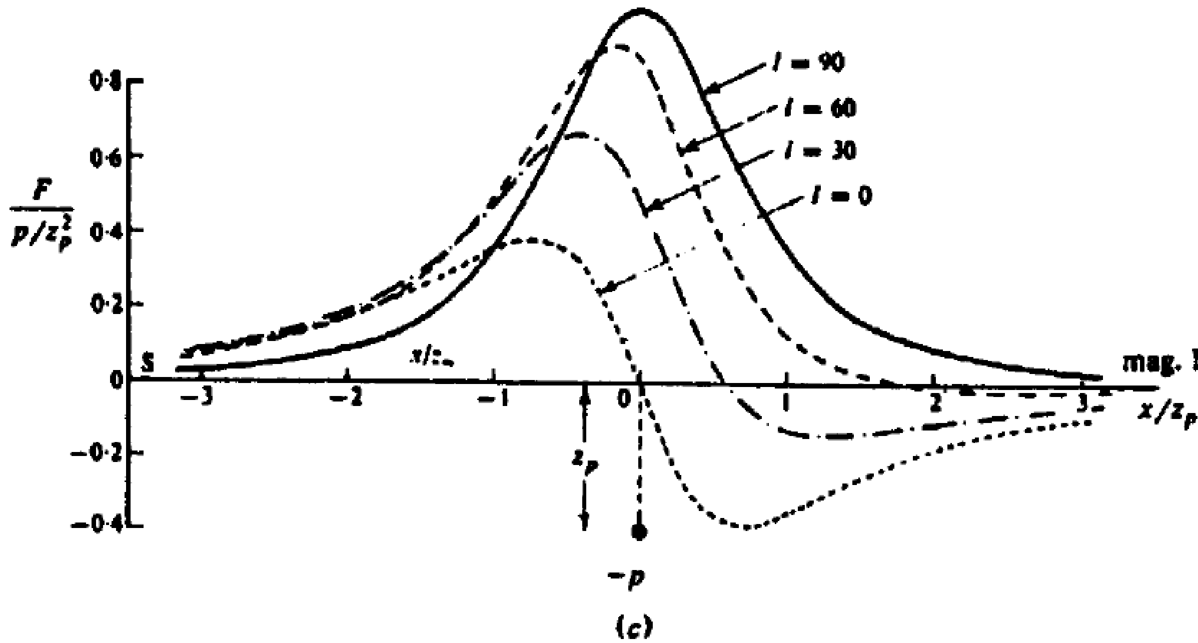
Once you have a usable data file in the MATLAB directory, run MagnetoBot.m. This will launch two windows. The left window shows an abbreviated template for inputting guesses and background magnetic fields. The right window is the one and only MagnetoBot! It should look something like the figure above.

Go immediately to the line that reads "`data_file_name[without extension]`" Do not pass GO, do not collect 200 dollars. Type in the name of the file with the data that you want to fit. Go to the lower right corner of the app and select the type of file you are using. Click "DISPLAY DATA" to display your data in blue o's on the GUI axis. If it doesn't plot, check again that the format of the data is correct, and that the file name is spelled correctly. Once you have plotted your first set of data, you can begin fitting.

Choosing the Right Model

This is what geophysics is all about. Fitting lines is fun and all, but understanding the magnetic model behind the data gives those lines real meaning and applications in the world.

Figure 2: MagnetoBot's Monopole Model (Telford et al., 1990).



Ok, enough soapboxing. You have three choices:

Option 1: The Monopole
This is a fictitious approximation, but it can be useful when one piece of a dipole is very far away and thus negligible. This model is based on Eq. 3.34b in Telford et al. 1991:

$F = (\frac{p}{r^3}(-xcos(I) + z_pcos(I))$
Where,
F **is the total magnetic field**
p **is the isolated pole**
x **is the horizontal distance from the pole**
z_p **is the depth to the pole**
I **is the inclination of the area**

NOTE: This model only uses Guesses for position, depth, susceptibility, offset, and slope. It only uses fixed inputs for inclination. Please put a "1" placeholder for any extra parameter.

Option 2: The Dipping Prism
This geometry is most commonly used for dikes and other steeply dipping, elongated rectangles with anomalous susceptibility. For this model strike and inclination are required and cannot be fitted. In addition, a rough approximation for the length of the dike will be used, as the fit becomes too unwieldy.

$$
\begin{aligned}
r_1^2 &= d^2 + (x + dcot(\xi))^2 \\
r_2^2 &= D^2 + (x + Dcot(\xi))^2 \\
r_3^2 &= d^2 + (x + dcot(\xi) - b)^2 \\
r_1^2 &= D^2 + (x + Dcot(\xi) - b)^2
\end{aligned}
\tag{1}
$$

And using the following equation for magnetic potential (Telford, 1990):

$$
A = (\frac{M}{\gamma\rho})g_a = -(\frac{M}{\gamma\rho})\nabla U \cdot f_1 \tag{2}
$$

where $f_1 = (cos(I)sin(\beta i') + sin(Ik))$ **Taking the gradient of potential to find the magnetic field, we find:**

$$
\begin{aligned}
&F = (\frac{\kappa F_e}{\gamma\rho})[... \\
&(U_{xx}cos(I)sin(\beta) + (U_{xz}sin(I))i')+ \\
&(U_{xz}cos(I)sin(\beta) + (U_{zz}sin(I))i')]
\end{aligned}
\tag{3}
$$

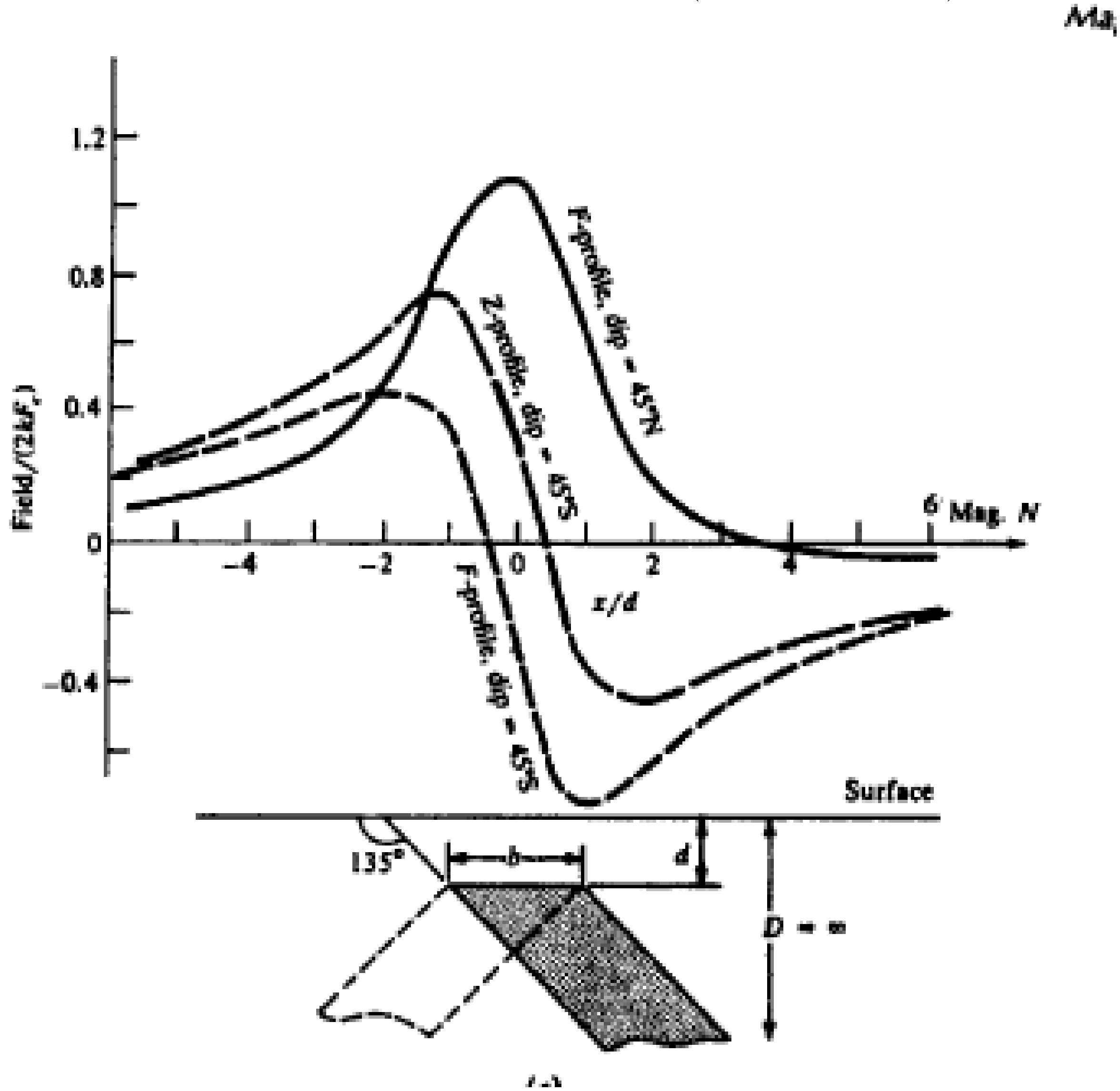
Equation 3.43 in Telford, 1990

Solving for all U's gives:

$$
\begin{aligned}
&F = 2\kappa F_e sin\xi[... \\
&(sin(2I)sin(\xi)sin(\beta) - sin(\xi)(cos^2(I)sin^2(\beta) - sin^2(I)) \times ln(\frac{r_2 r_3}{r_1 r_4}) + ... \\
&sin(2I)cos(\xi)sin(\beta) + sin(\xi)(cos^2(I)sin^2(\beta) - sin^2(I)) \times (\phi_1 - \phi_2 - \phi_3 + \phi_4)
\end{aligned}
\tag{4}
$$

Where,
κ = **the susceptibility of the dike material**
F_e = **magnetic polarization**
ξ = **dip of dike (in degrees counterclockwise from North)**
I = inclination
β = **strike of the dike**
r_i = **radius to the corners of the dike**
ϕ_i = **angles to these corners**

Figure 3: MagnetoBot's Dipping Prism Model (Telford et al., 1990).



Option 3: The Semi-Infinite Sheet
This geometry is useful to model faults which have placed two beds of differing susceptibility next to each other. For this model strike and inclination are required and cannot be fitted. However, the width of the anomalous bed will be fitted. Note that the dip value for this model is the dip of the fault plane, not the bed itself.

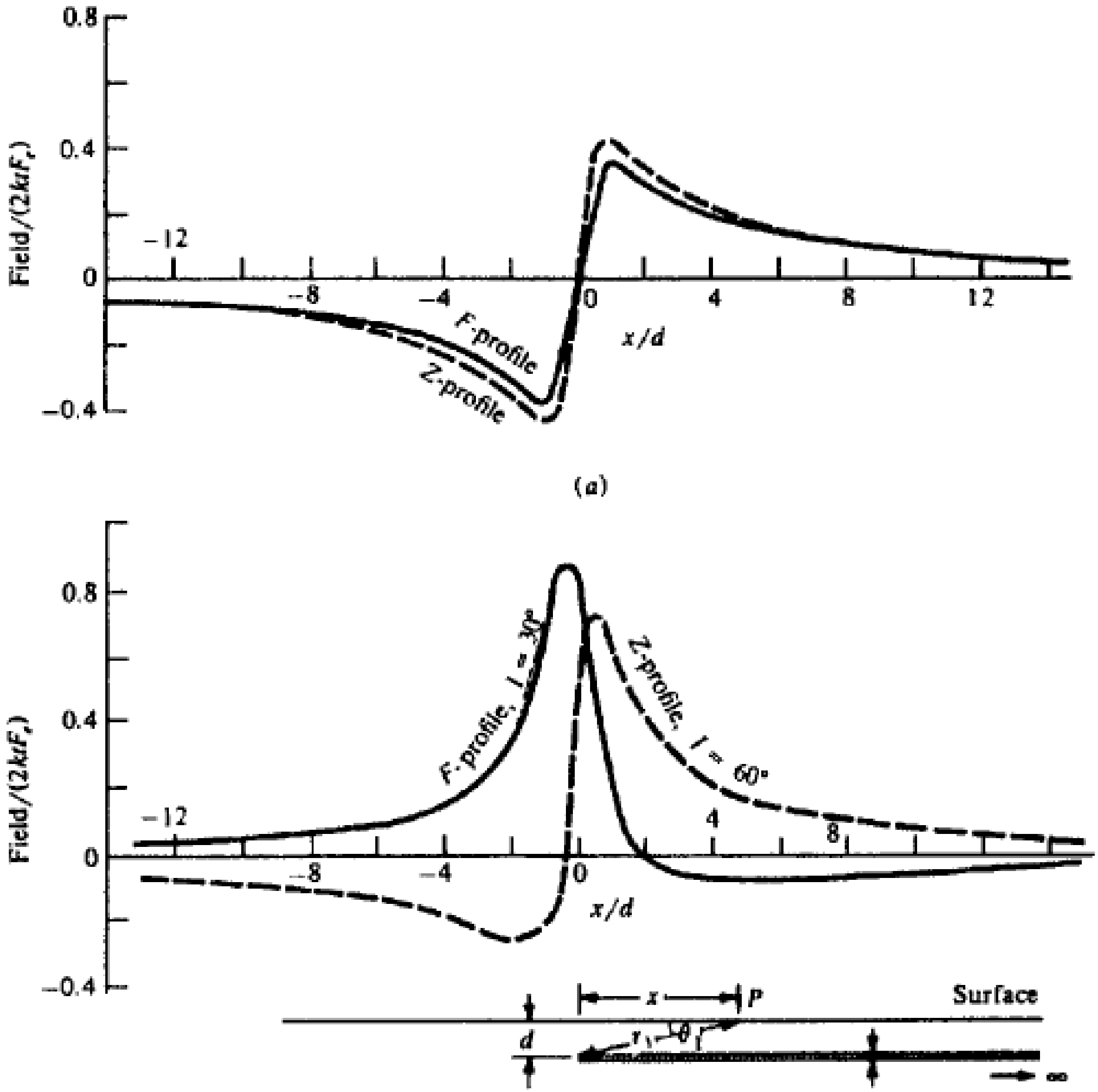
$$r_1^2 = d^2 + (x + dcot(\xi))^2$$
$$r_2^2 = D^2 + (x + Dcot(\xi))^2 \tag{5}$$

And using the following equation for magnetic field (Telford, 1990):

$$
\begin{aligned}
&F = 2\kappa F_e sin\xi[... \\
&(1/r_1^2)\{(dcos(I)sin(B) + (x + dcot(\xi))sin(I)\} - ... \\
&(1/r_2^2)\{(Dcos(I)sin(B) + (x + Dcot(\xi))sin(I)\}
\end{aligned}
\tag{6}
$$

Where,
κ **= the susceptibility of the dike material**
F_e **= magnetic polarization**
ξ **= dip of the fault plane**
I **= inclination**
β **= strike of the fault plane (in degrees counterclockwise from North)**
r_i **= radius to the edges of the fault plane**
ϕ_i **= angles to these edges**

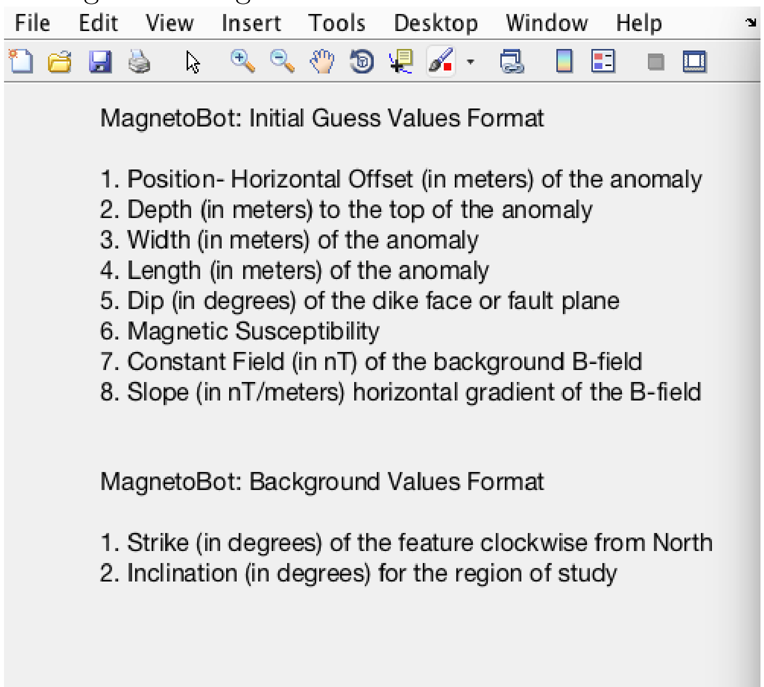
Figure 4: MagnetoBot's Semi-Infinite Sheet Model (Telford et al., 1990).



MagnetoBot Cheat Sheet Instructions

I have included a set of instructions (below), to help the user know which values go where. It should pop up on the left hand side of the screen every time you run MagnetoBot. Reference this for units, meaning, and what is used where.

Figure 5: MagnetoBot Cheat Sheet Instructions



Making Guesses

Once you choose the model you want to use, start inputting guess values on the left hand side. I recommend the following technique:
1] Start with an insanely high susceptibility value, to get the shape and location of the profile
2] Lower the susceptibility, and hone other parameters to get the guess as close to the data as possible
3] Clear the data using the "CLEAR" button
4] Fit the data using the "FIT NOW" button
5] The fitted values will be returned in the command window of MATLAB.

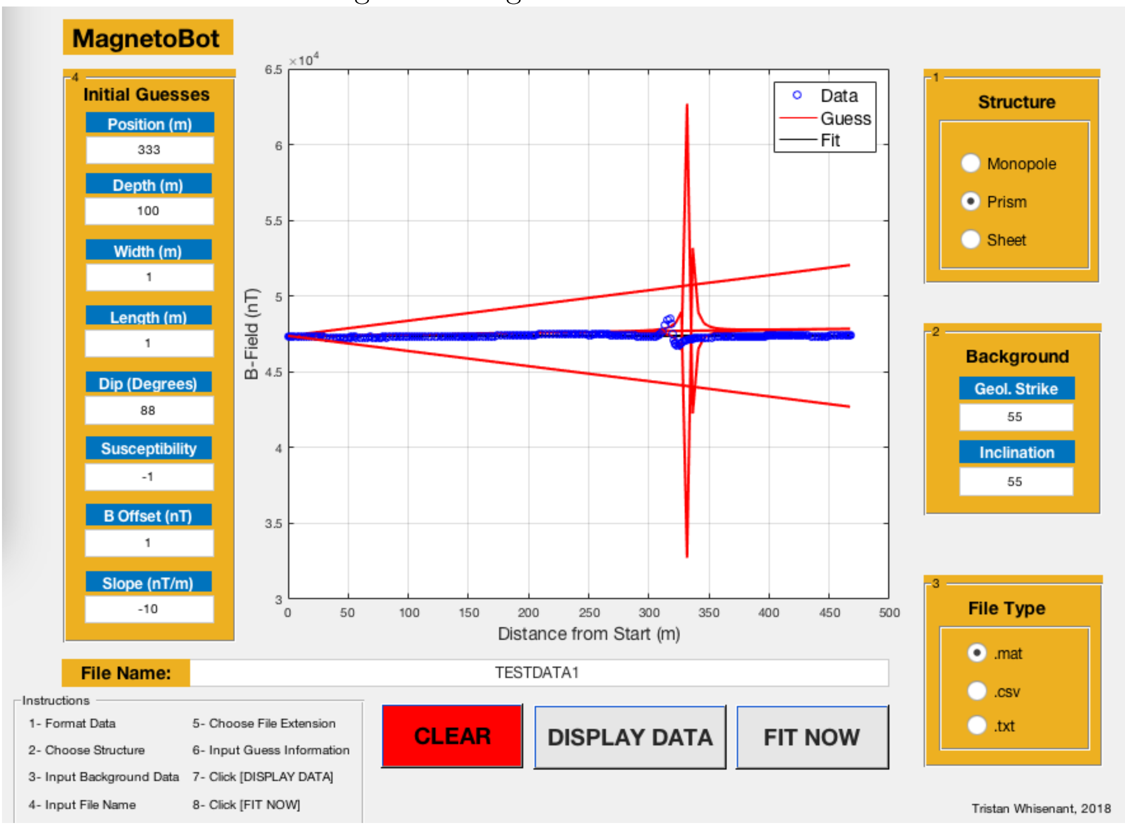
Clearing Guesses

If you're really awful at guessing like I am (see below), use the "CLEAR" button to eliminate old guesses while keeping your guess progress. To start from scratch, closes the window.

Evaluating Fits

Along with the fitted values returned in the command window, standard deviations for each guess will also be included, free of charge. These allow for a data-driven evaluation of the accuracy of each parameter. To put a number to

Figure 6: MagnetoBot Bad Guesses



this, at 1 standard deviation away from the fitted value, there is 68 % probability of including the true value, and 2 standard deviations, there is 95 % probability. The errors included in the command window Fit feedback are 3 standard deviations (more than 99 %).

Saving Data

MagnetoBot automatically puts the data profile, fits, guesses, and standard deviation into a .mat file named MagnetoBot_Out.mat. This will be overwritten every time you run MagnetoBot, so make sure to move over valuable data.

Good Luck and Happy Hunting

I had a great time making this project for the capstone class of my UCLA Geophysics Major. I'm graduating tonight!