

2-D Electric Potential and Field Visualizer Presentation

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Outline

- Motivation
- Introduction
- Background
- Display Options
- Charge Options
- Other Windows
- Demonstration Example
- Feedback

Motivation

- Electromagnetics theory is unintuitive and hard to engage with for many.
- Experimentation can enable greater understanding of concepts but is often infeasible.
- Software can have many of the benefits of experimentation while also being more realizable.

Introduction

- Presenting, the "2-D Electric Potential and Field Visualizer" as seen in Fig. 1

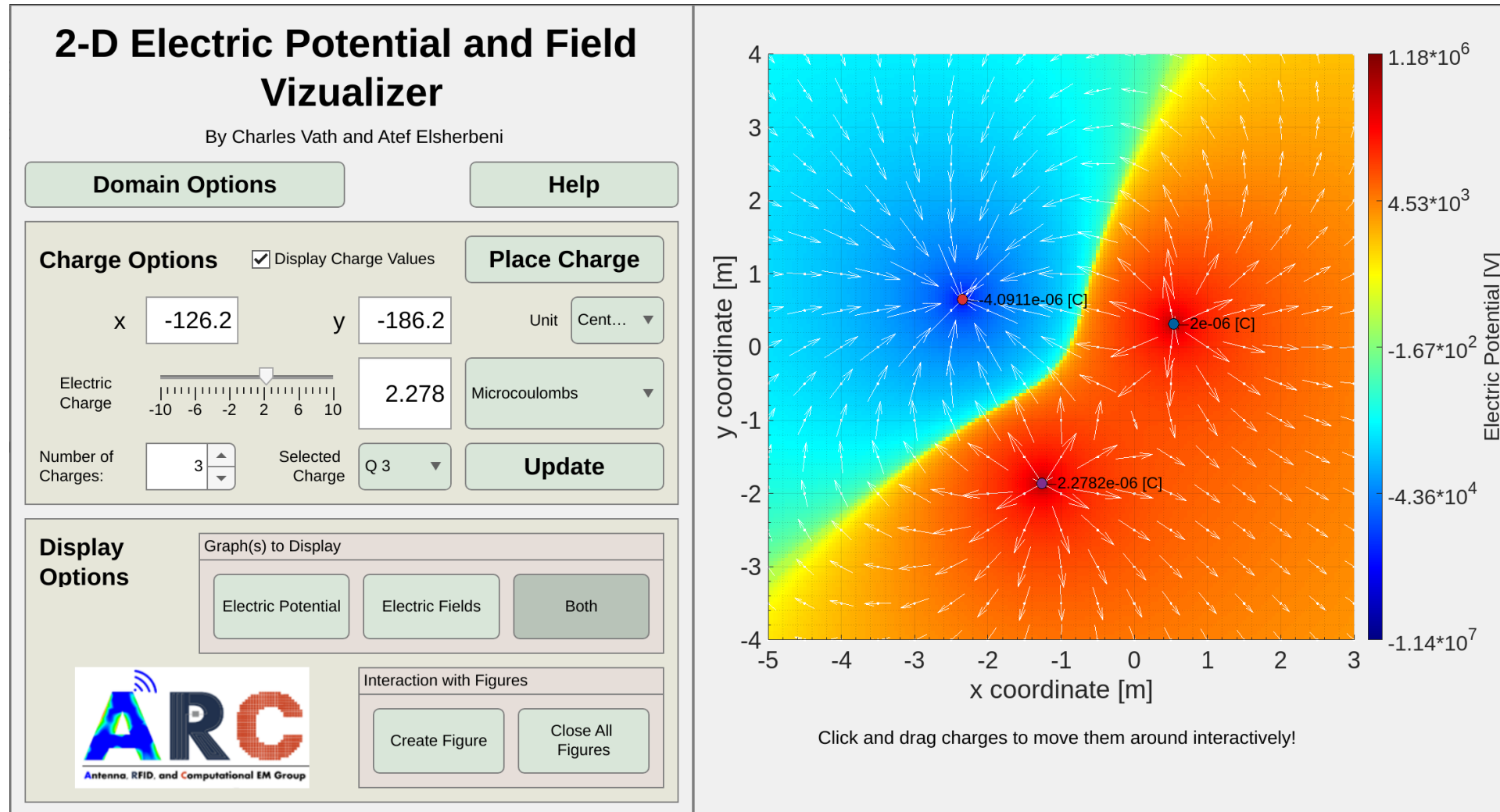


Fig. 1. Picture of the main application with a plot of the electric potential and electric field vectors together.

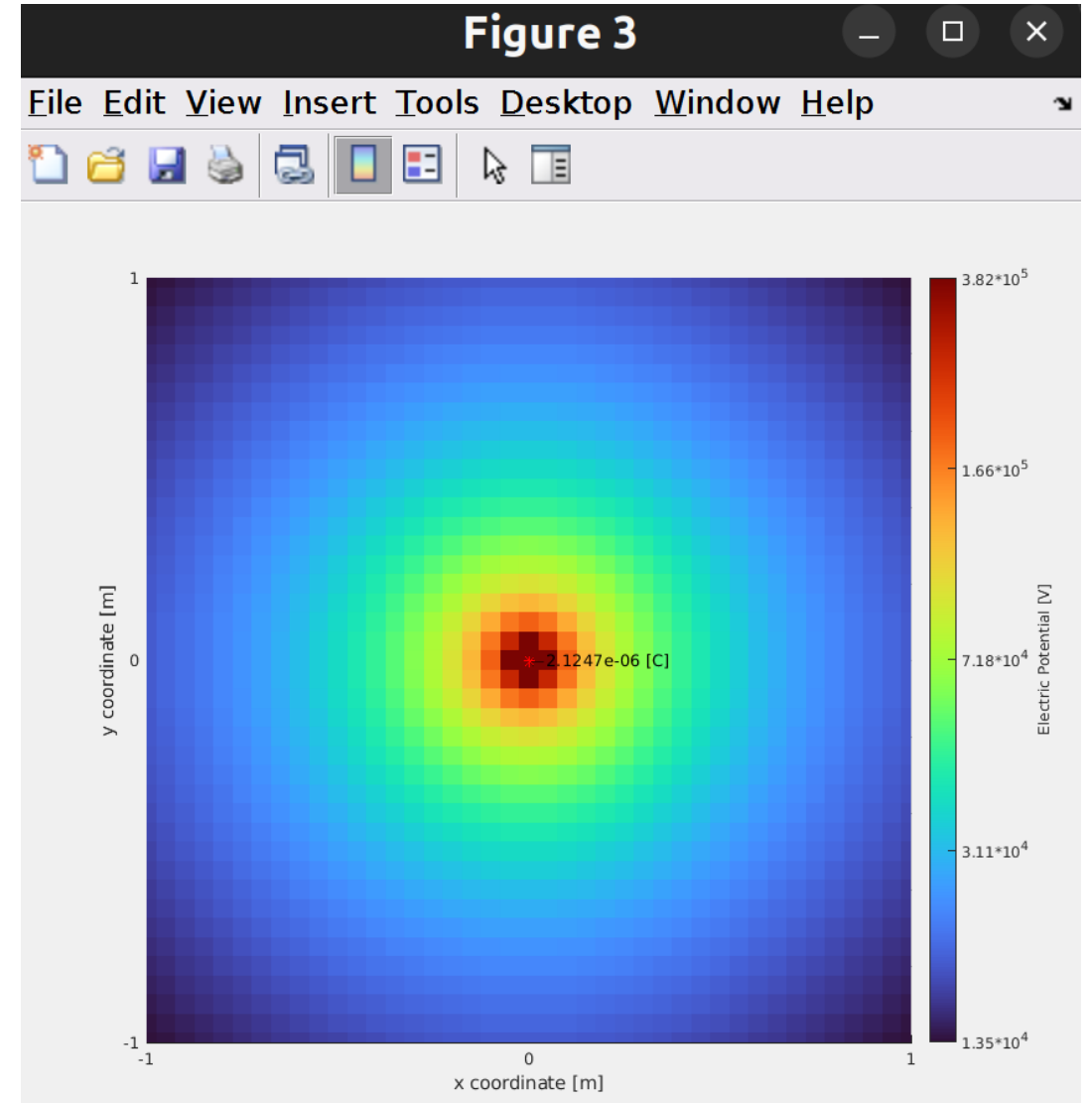
Background

- App is developed in MATLAB App Designer with MATLAB R2023b and the MATLAB Image Processing Toolbox.
- Simulates electrostatics conditions for point charges.
- App allows user interaction and real-time visualization of electric field and potential distributions due to user defined charges.

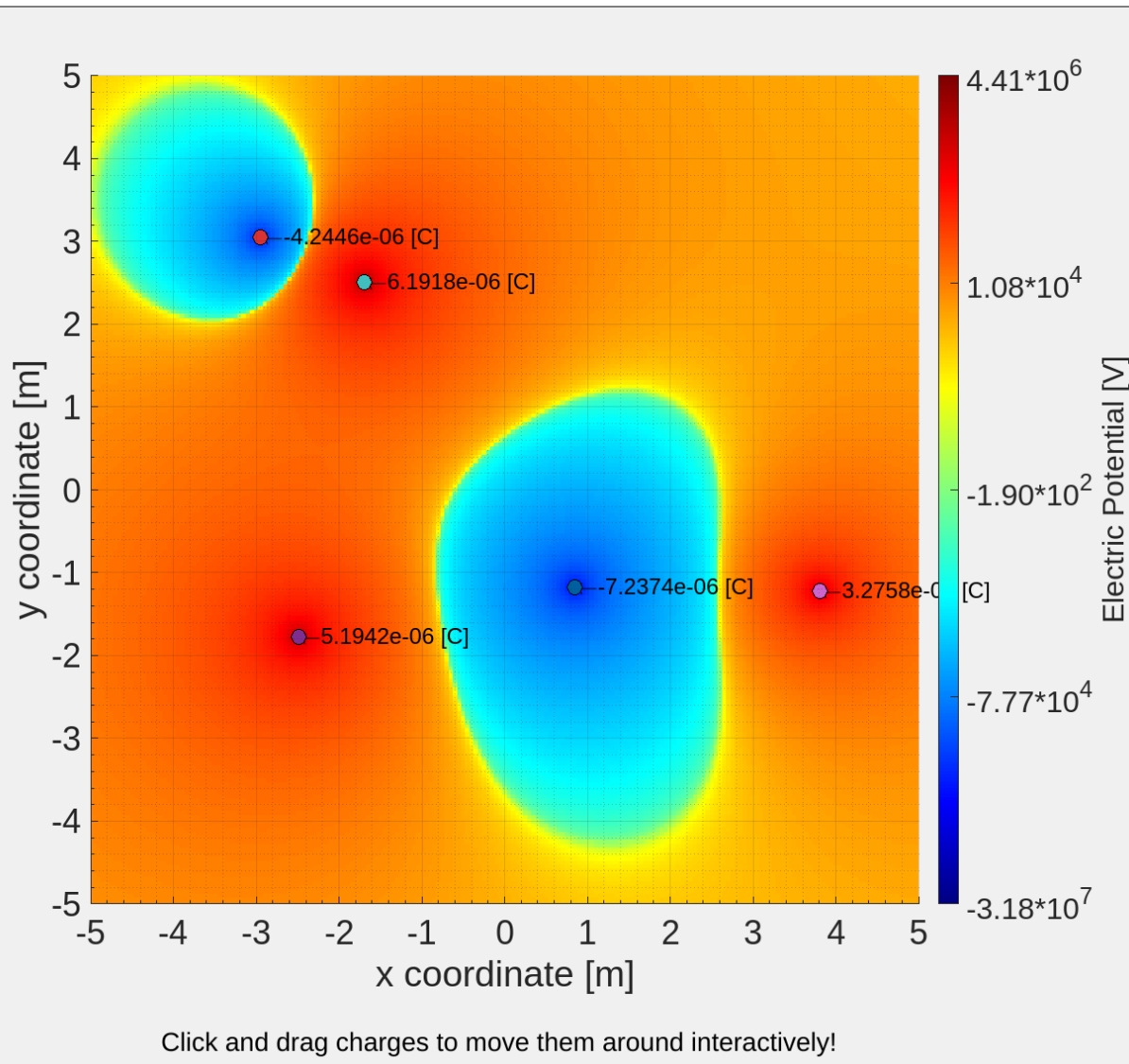
Display Options

- Graphs can display electric field vectors, electric potential, or both.
- Graphs can be displayed on the UI axes or static figures.
- Graphs have color bars showing the levels of displayed colors.

Fig. 2. A static figure window displaying electric potential.



Display Options – UI Axes

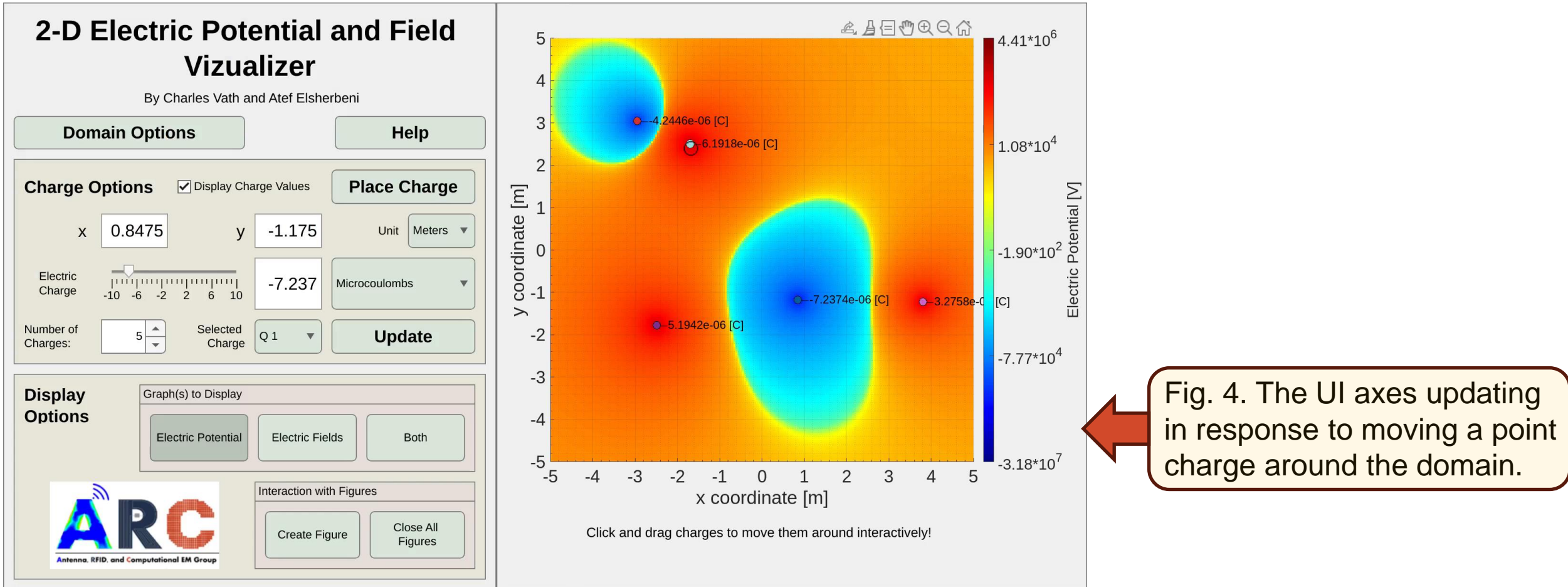


- The UI axes correspond to the graph on the right side of the main application window as seen in Fig. 3.
- The UI axes display the charges in different colors for each charge as seen in Fig. 3.

Fig. 3. A cropped image of the UI axes. 5 charges of differing polarities and magnitudes exist in the domain shown.

Display Options – UI Axes

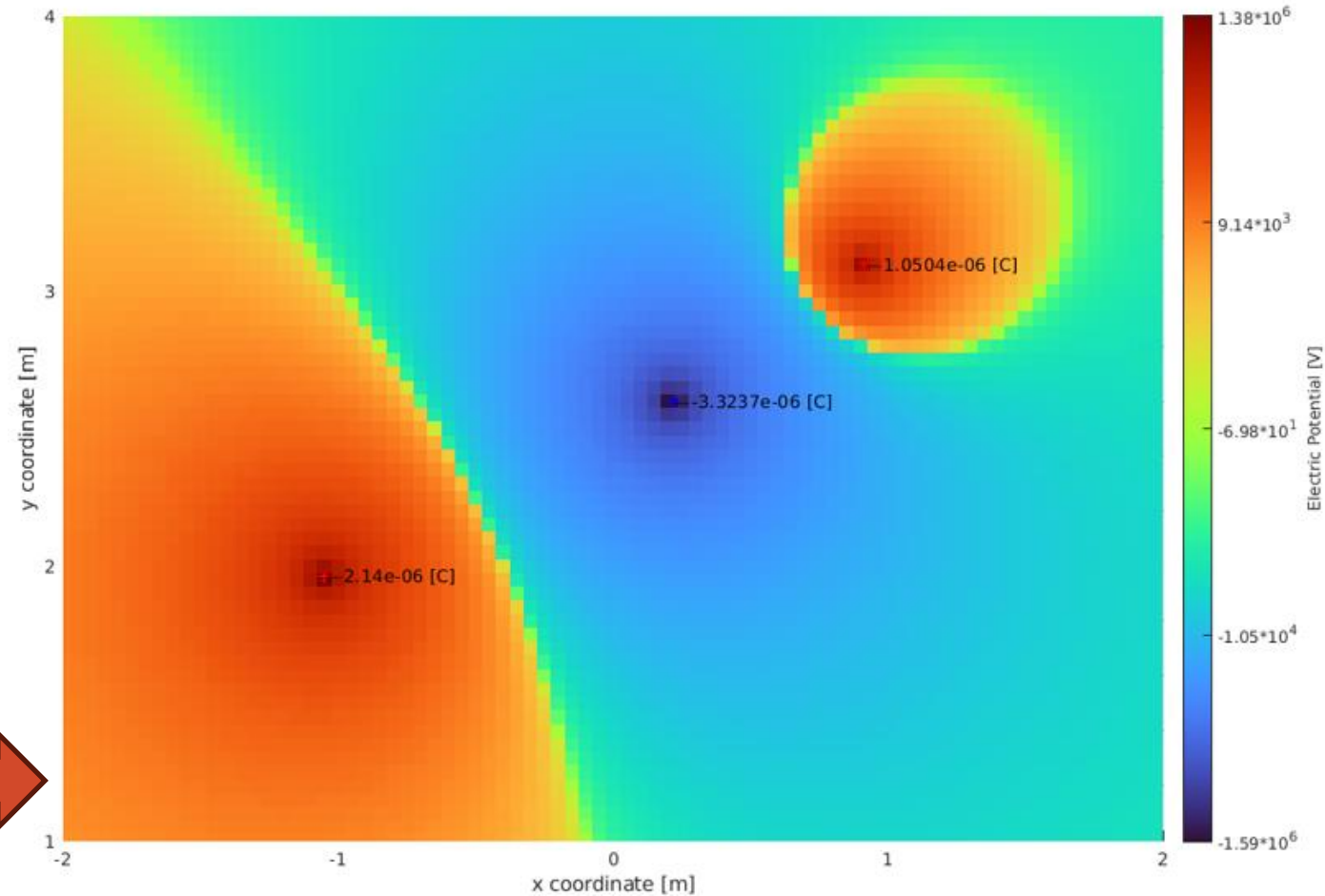
The UI axes are meant to update in response to user input that triggers app updates; see Fig. 4 for a video of this principle.



Display Options – Static Figures

- Static figures are MATLAB figure windows generated by clicking the 'Create Figure' button.
- Static figures also show the charges themselves with either a red asterisk for positive charges or a blue asterisk for negative charges as seen in Fig. 5.

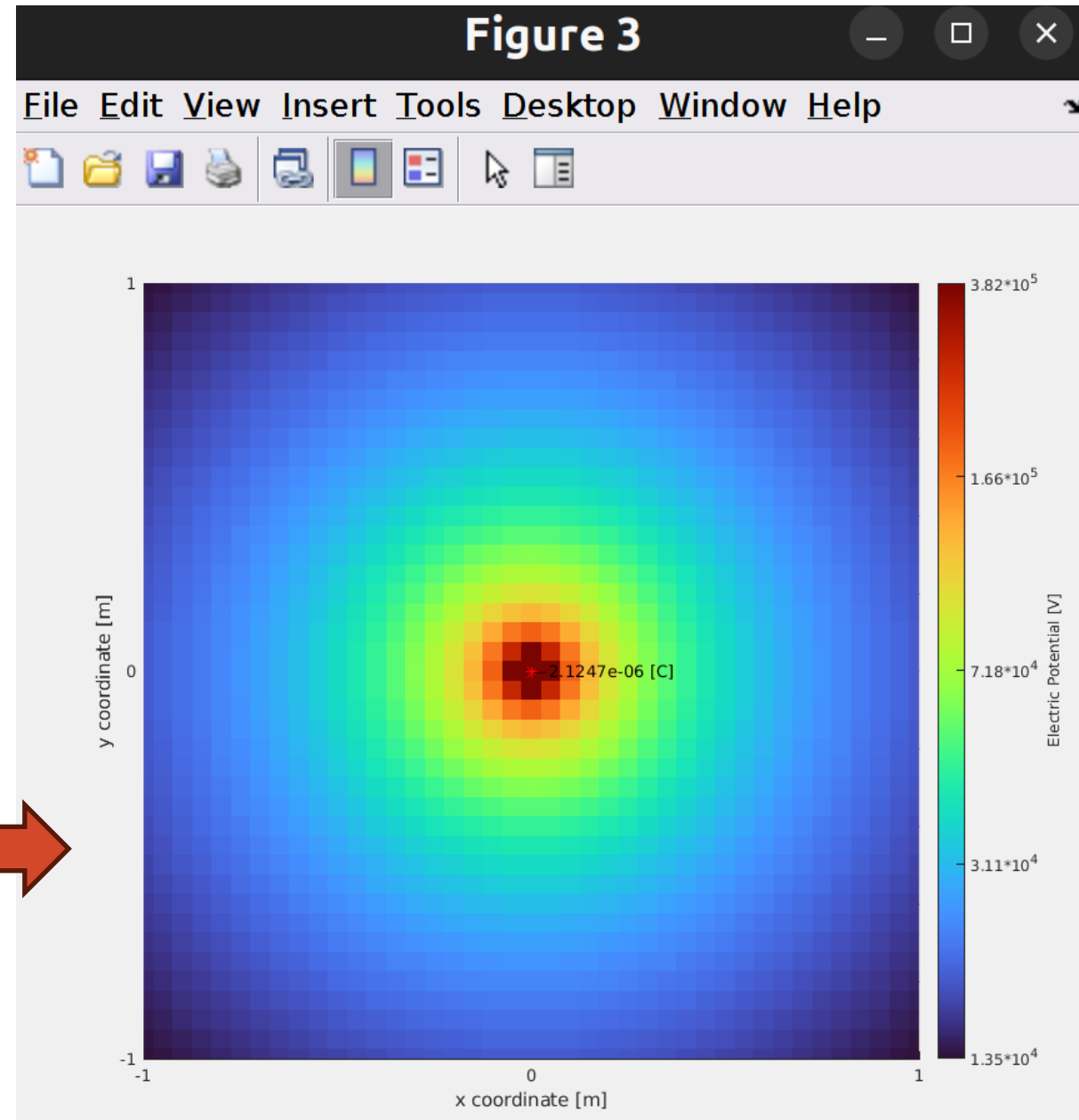
Fig. 5. A cropped static figure window of the electric potential due to 3 point charges. The domain the charges reside in has been changed via 'Domain Options' window to be seen later.



Display Options – Static Figures

Static figures do not update to changes made in the app with the exception of pressing the 'Close All Figures' button.

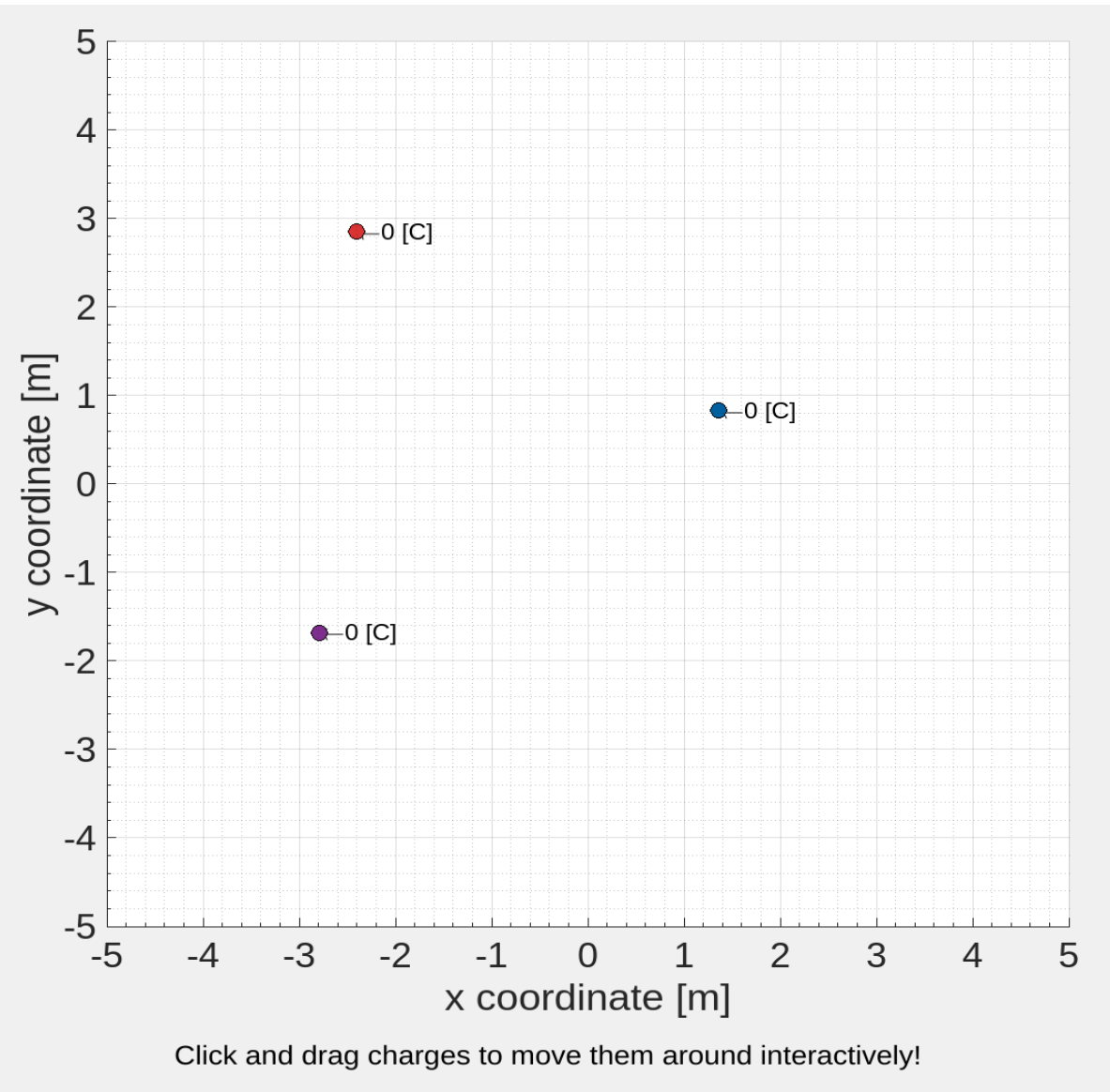
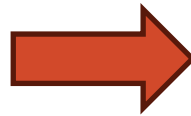
Fig. 6. A static figure window with an especially small domain and one point charge. The MATLAB figure features can also be seen.



Display Options - Other

- Graphs of only electric field vectors display the electric field magnitude in the color bar.
- Other graph options display the electric potential in the color bar.
- Color bars may not show if no charge is present in the domain as seen in Fig. 7.

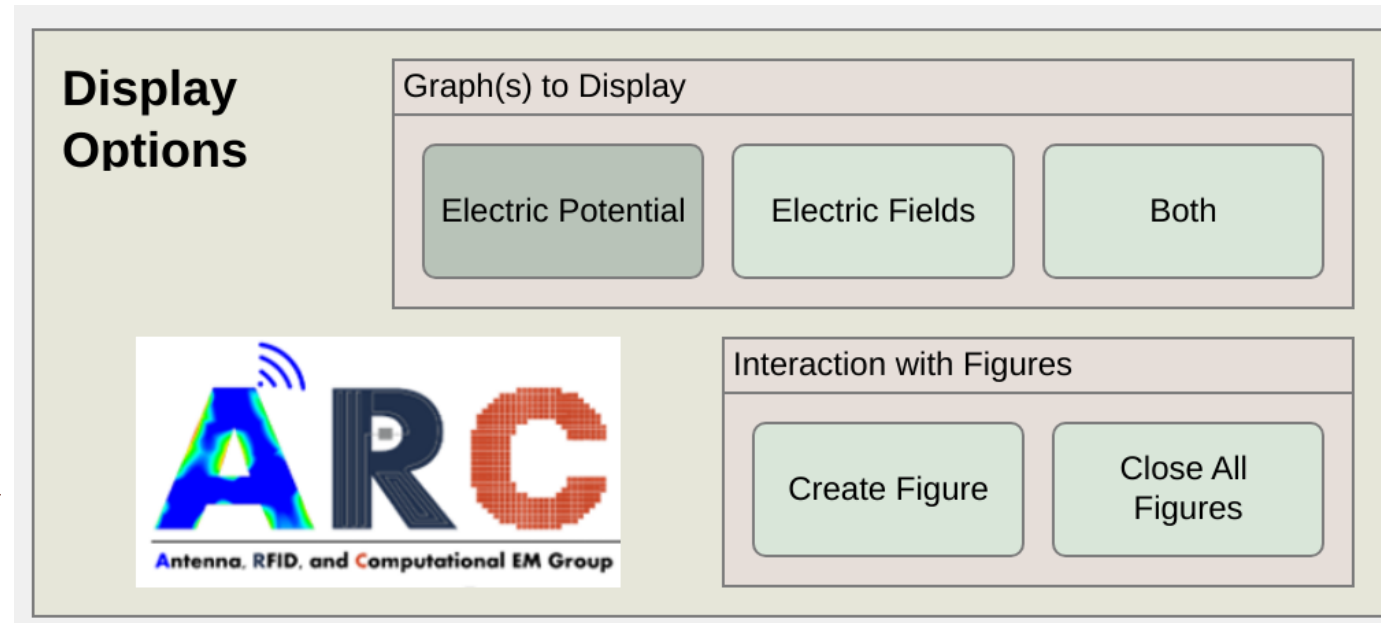
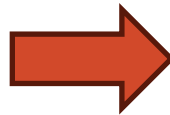
Fig. 7. A UI axes graph with no color bar due to the absence of any charge in the domain.



Display Options – Other

- The Display Options section is seen in Fig. 8.
- The 'Graph(s) to Display' subsection is where the user can select between displaying the electric potential, electric fields, or both.
- The 'Interaction with Figures' subsection is where the user can create a figure or close all figures.

Fig. 8. Zoomed in image on the 'Display Options' section.



Charge Options

- The quantity, position, and charge magnitude of point charges can be changed.
- Changing point charge data can take place interactively or through precise input such as in fields shown in Fig. 9.

Fig. 9. Charge options set with certain parameters.

The screenshot displays the 'Charge Options' interface with the following elements:

- Charge Options** title and a checked checkbox for **Display Charge Values**.
- Place Charge** button.
- x** coordinate input field: -126.2
- y** coordinate input field: -186.2
- Unit** dropdown menu: Cent...
- Electric Charge** input field: 2.278
- Microcoulombs** dropdown menu.
- Number of Charges** input field: 3
- Selected Charge** dropdown menu: Q 3
- Update** button.

The Electric Charge field includes a slider ranging from -10 to 10, with the current value of 2.278 indicated by a white triangle on the scale.

Charge Options – Update ‘Buffered’ Features

- Update buffered features depend on updates to result in changes to application display.
- the ‘Update’ button seen in Fig. 10. and some other features like interactive features can trigger an update in the application.



Fig. 10. The ‘Update’ button in the main app.

Charge Options – Update ‘Buffered’ Features

- Charge quantity can be changed by the entry field seen in Fig. 11.
- The charge to operate on can be changed by the drop down field seen in Fig. 12.

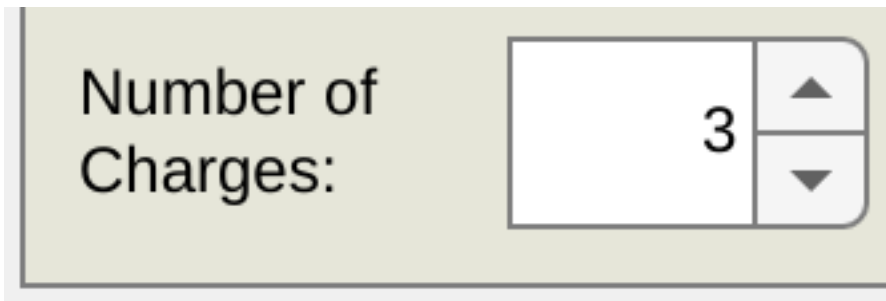


Fig. 11. The ‘Number of Charges’ entry field set to 3.

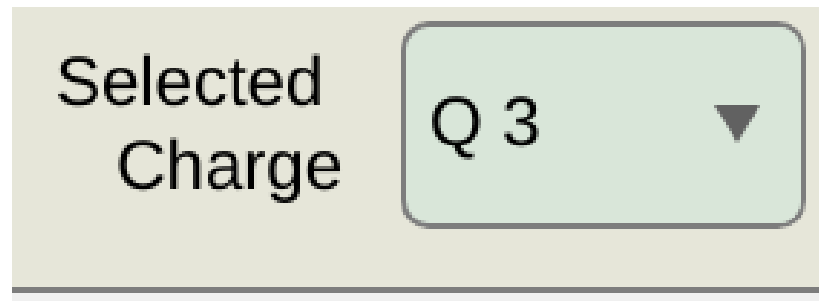
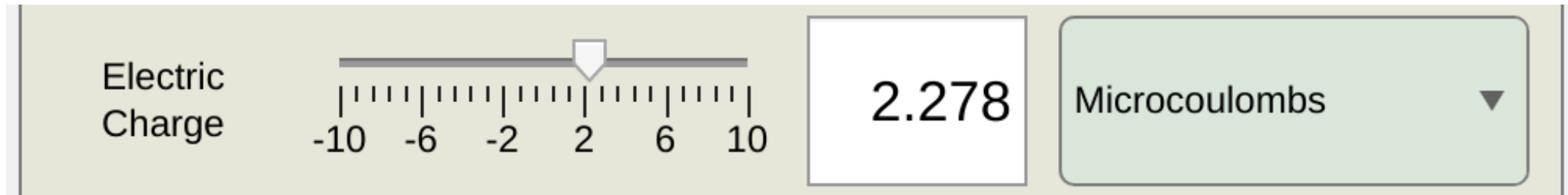


Fig. 12. The ‘Selected Charge’ entry field set to Q 3, or charge 3.

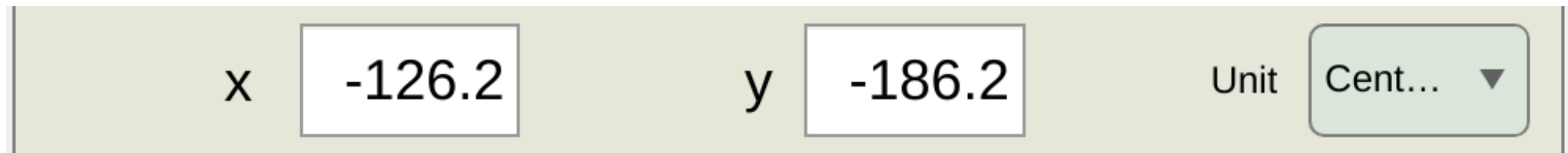
Charge Options – Update ‘Buffered’ Features

- Charge magnitude and units can be changed by the entry fields seen in Fig. 13.
- Charge position can be changed by the entry fields seen in Fig. 14.



The screenshot shows a control panel for 'Electric Charge'. On the left, the text 'Electric Charge' is displayed. To its right is a horizontal slider with a white triangular handle. The slider's scale is marked with numerical values: -10, -6, -2, 2, 6, and 10. The handle is positioned at the value 2.278. To the right of the slider is a white text input field containing the number '2.278'. Further right is a green rounded rectangular button with the text 'Microcoulombs' and a downward-pointing triangle, indicating a dropdown menu.

Fig. 13. The slider, text input field, and unit drop down field for changing the charge magnitude of a given point charge.



The screenshot shows a control panel for setting charge coordinates. It features two white text input fields. The first is labeled 'x' and contains the value '-126.2'. The second is labeled 'y' and contains the value '-186.2'. To the right of these fields is a green rounded rectangular button with the text 'Unit' and 'Cent...' followed by a downward-pointing triangle, indicating a dropdown menu.

Fig. 14. The x and y input fields and unit drop down field for changing the coordinates of a given point charge.

Charge Options – Interactive Features

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Domain Options

Help

Charge Options

Display Charge Values

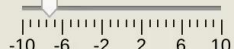
Place Charge

x 0.8475

y -1.175

Unit Meters

Electric Charge



-7.237

Microcoulombs

Number of Charges:

5

Selected Charge

Q 1

Update

Display Options

Graph(s) to Display

Electric Potential

Electric Fields

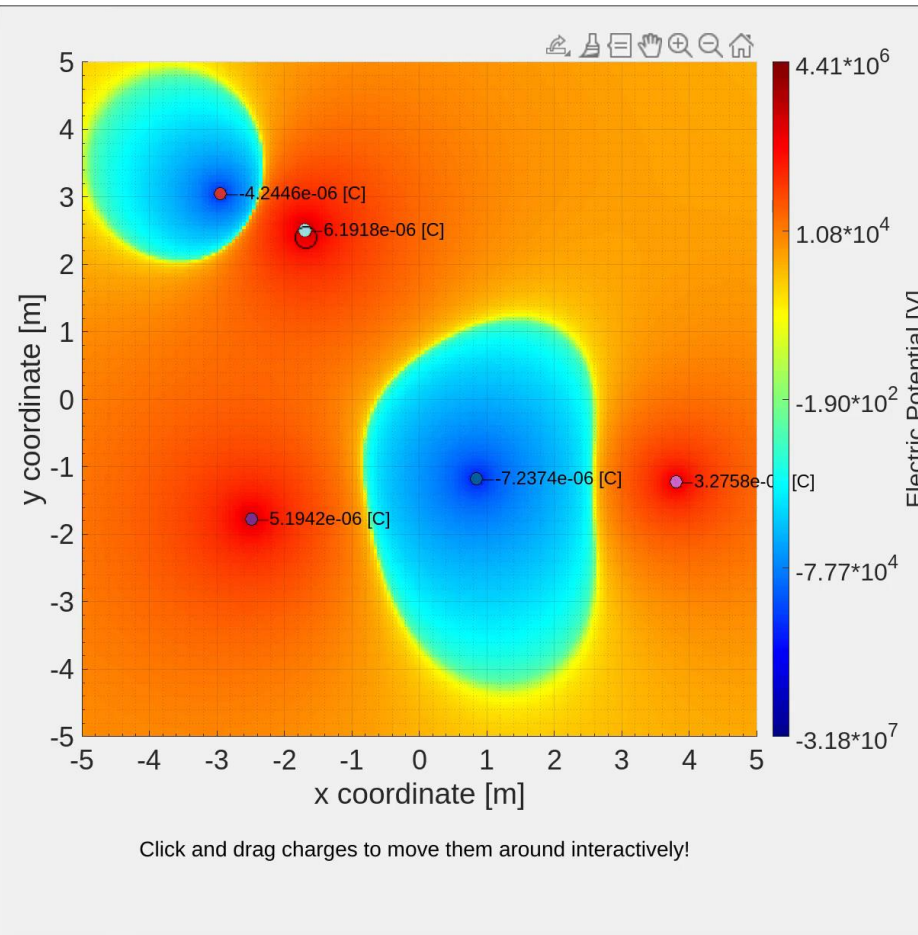
Both



Interaction with Figures

Create Figure

Close All Figures



Moving Point Charges

- Point charges can be clicked and dragged around the domain.
- While moving, the app can render updates to the UI axes in near real time.
- Updates are also displayed after the charges are moved around.

Fig. 15. Clicking and dragging a charge around the domain.

Charge Options – Interactive Features

Charge Magnitude Slider

- Similar operation to moving point charges around but this time for a slider.

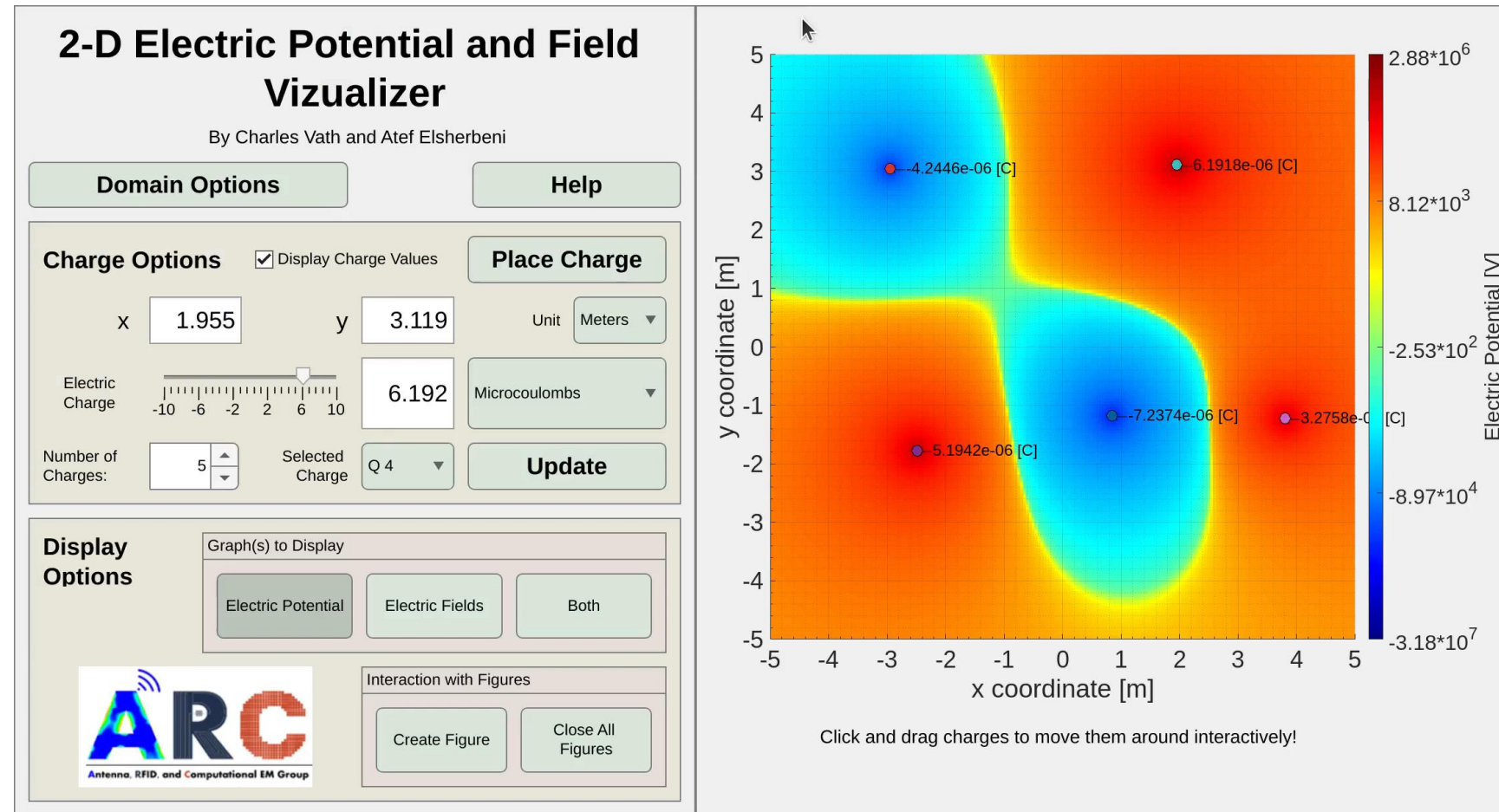


Fig. 16. Using the charge slider to interactively change charge 4's magnitude.

Charge Options – Interactive Features

Place Charge

- Place Charge button seen in Fig. 17.
- When under max point charge capacity, pressing place charge and pressing again somewhere on the UI axes places a charge as seen in Fig. 17.

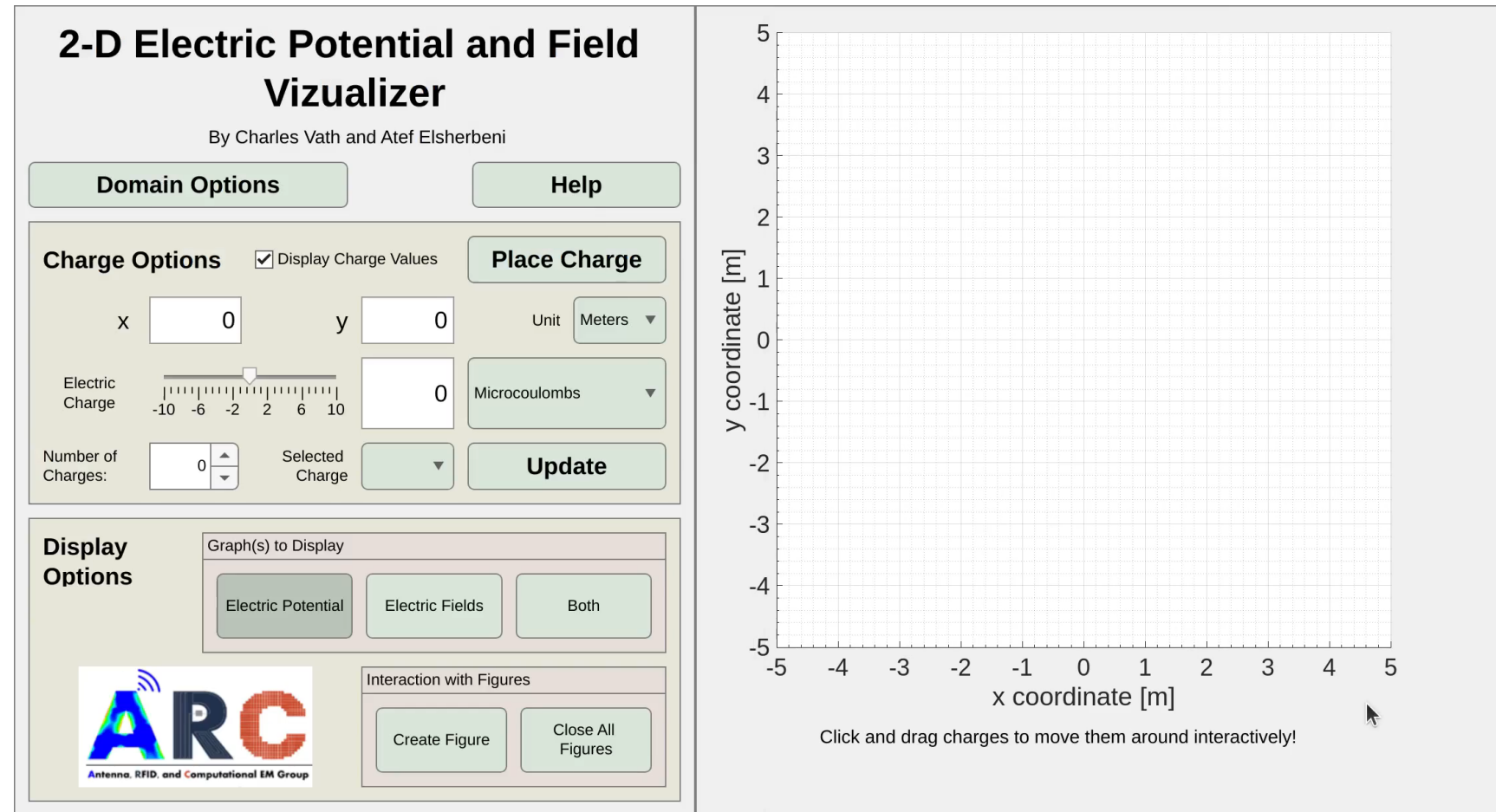


Fig. 17. The 'Place Charge' button in action with the number of charges at less than maximum.

Charge Options – Interactive Features

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Domain Options

Help

Charge Options

Display Charge Values

Place Charge

x 3.175

y 3.412

Unit Meters

Electric Charge

-10 -6 -2 2 6 10

2.815

Microcoulombs

Number of Charges:

5

Selected Charge

Q 4

Update

Display Options

Graph(s) to Display

Electric Potential

Electric Fields

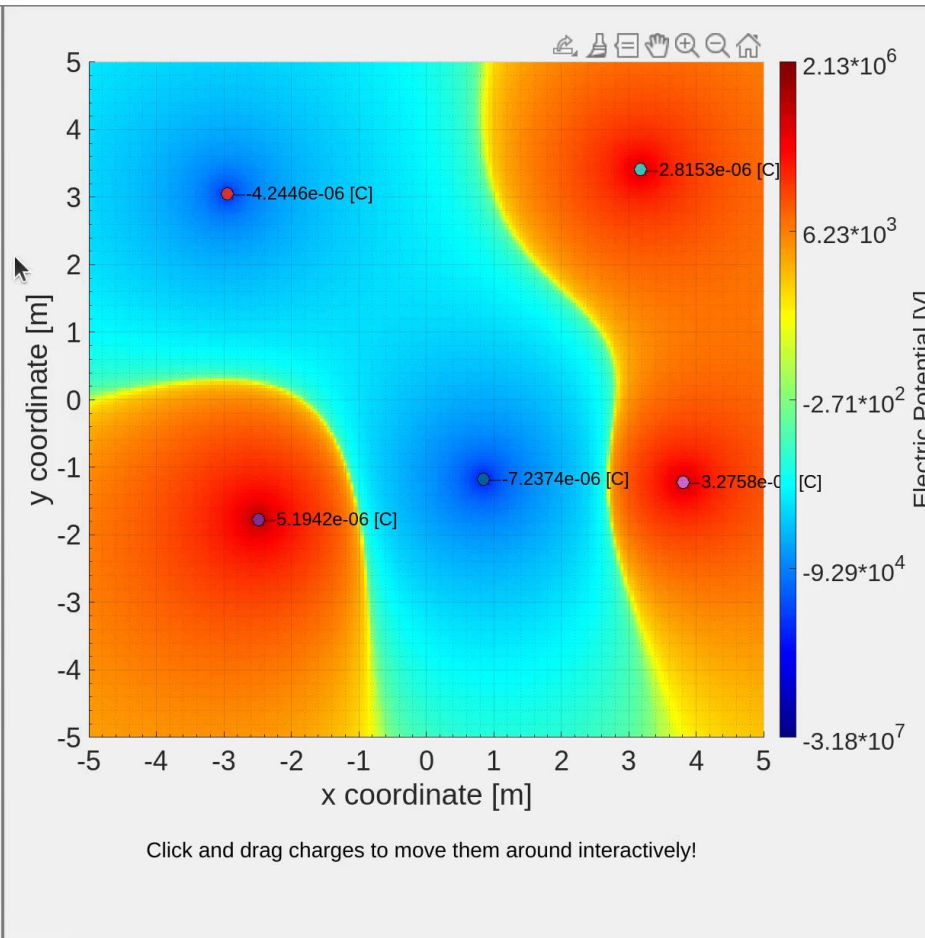
Both



Interaction with Figures

Create Figure

Close All Figures



Place Charge

- Placing a charge when at max charge capacity instead moves the charge 'at capacity' around the screen as seen in Fig. 18.

Fig. 18. Placing a charge with the maximum number of charges already existing causing a charge to be re-placed.

Other Windows – Domain Options

Domain Options

Set the lower and upper bounds of the x dimension, the y dimension, and the units. Click "Save Options and Close" to return to the main window

Upper x Upper y

Lower x Lower y

Unit Meters

- 'Domain Options' allows for defining the boundaries of the simulation domain.
 - This is basically the x and y limits and their units.
- The 'Domain Options' window restricts domain options deemed to be in error as seen in Fig. 19

Fig. 19. The 'Domain Options' window with options the x limits to $[-2, 2]$, and the y limits set to $[1, 4]$. The units are in meters.

Other Windows – Help Window

- The 'Help Window' seen in Fig. 20 is a window that can pop up and give basic information about the application.
- For example, trying to edit the application with an error window existent can cause the help window to pop up.

Charge Options Help

Either click "Place Charges" to use the mouse to place a point charge by clicking, or edit the appropriate windows. Then one can use the slider to give the charge of the point charge. Click "Update" to get the graph to render changes user may make in the charge. Existing charges can be clicked and dragged on the graph, or modified with the charge slider, without needing to press "Update".

Display Options Help

The buttons for "Electric Potential", "Electric Field", and "Electric Potential and Fields" are mutually exclusive, and display the corresponding graph. "Create Figure" creates a MATLAB figure of the current graph, provided there is one to create. "Close All Figures" closes all figures currently open.

The user manual gives a guide and example(s) to using the program.

Please close popup windows to aid app function!

User Manual

Technical Manual

Close Help Window

Fig. 20. The 'Help Window' for the application. Neither the 'User Manual' and 'Technical Manual' are complete as of time of writing.

Other Windows – Warning/Error Window

- Warning and error windows may pop up when the user does an action deemed invalid.
- Various types of errors and warnings exist, as seen in Figs. 21 and 22.

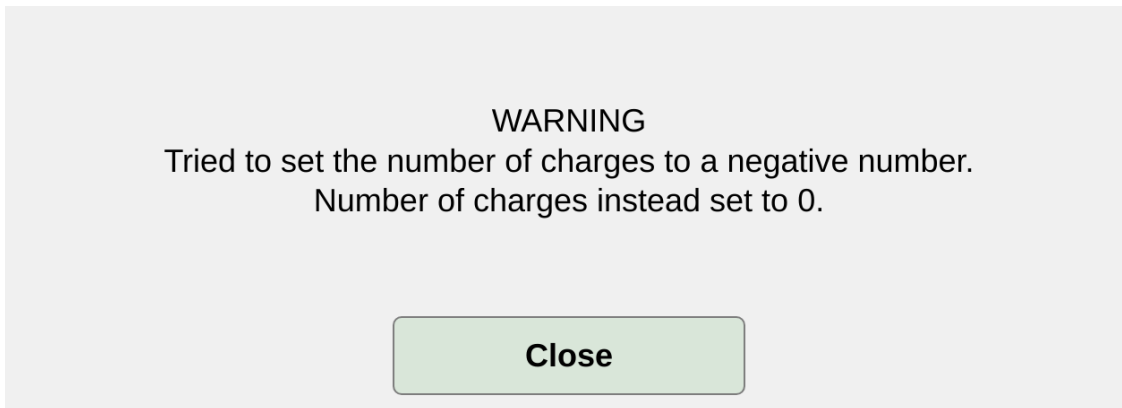


Fig. 21. A warning displayed by the application when trying to set a negative number of charges.

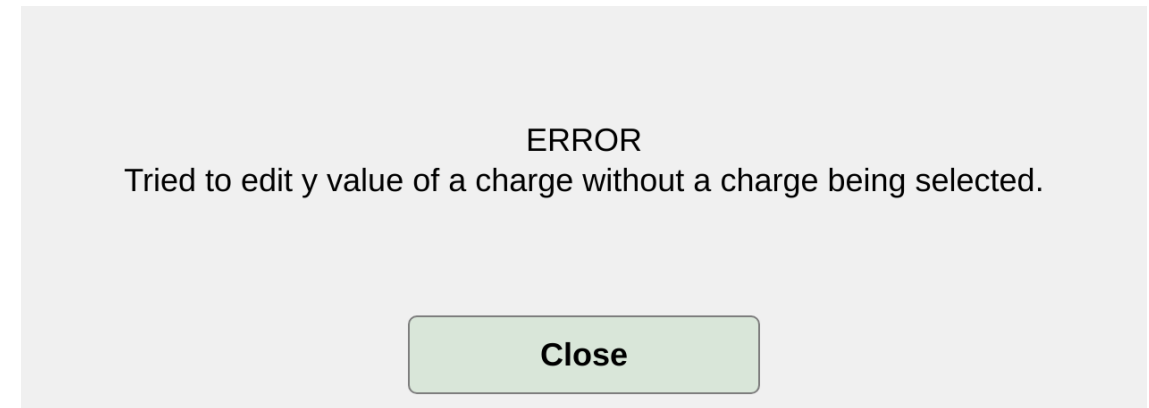


Fig. 22. An error given by the application when trying to edit data for a point charge that doesn't exist.

Demonstration Example

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Domain Options

Help

Charge Options

Display Charge Values

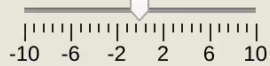
Place Charge

x 0

y 0

Unit Meters

Electric Charge



0

Microcoulombs

Number of Charges:

0

Selected Charge

Update

Display Options

Graph(s) to Display

Electric Potential

Electric Fields

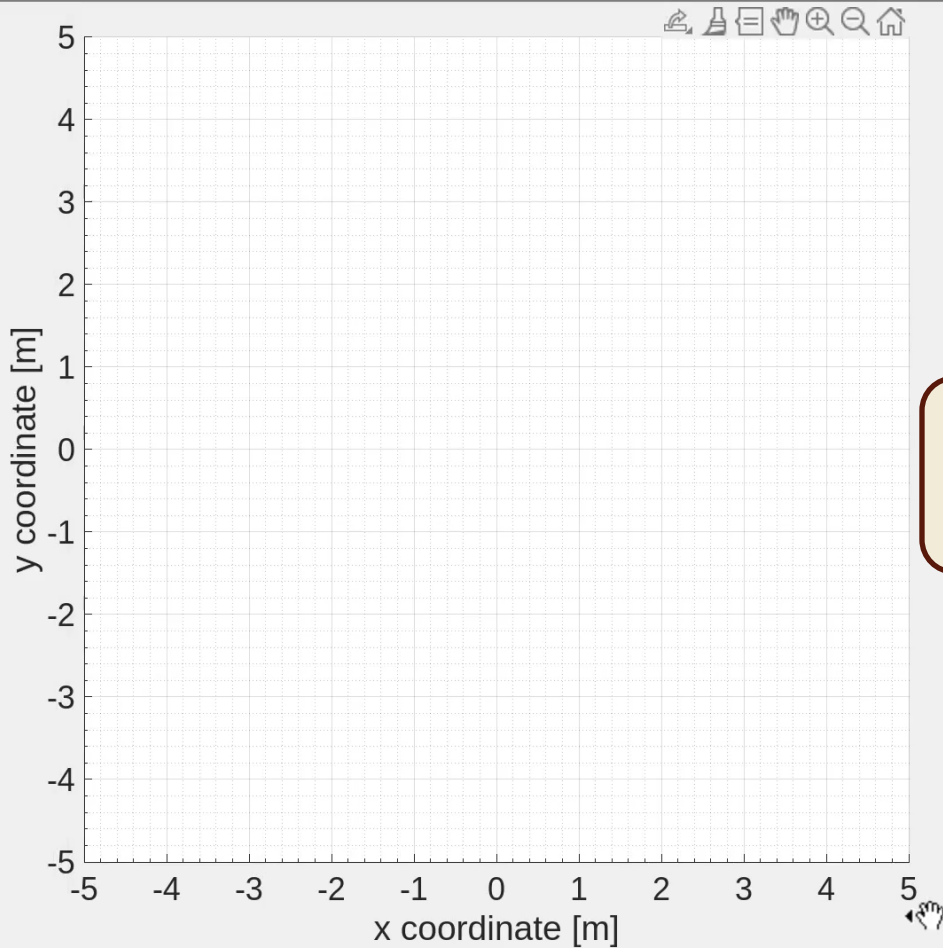
Both



Interaction with Figures

Create Figure

Close All Figures



Click and drag charges to move them around interactively!

Fig. 23. A demonstration of the application using many features discussed.

Feedback

Comments and questions are welcome