P.I.M. Tool

Instruction Guide

By Dan Gibbons

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1.

Intro

The P.I.M. Tool or Pressure Image Manipulation Tool, designed by Daniel Gibbons and Dr. Nathan Thompson, is a MATLAB program designed to intake Pressure Plate data produced by emed® sensor platforms. emed®-systems produce .txt data files in a specific format that, when processed, can be visually displayed to show the dynamic pressure distribution across a variable time frame. Foot plantar pressure showing ground reaction forces is a primary example of scientific inquiry that would benefit from visual reproduction of pressure measurements. While the vast majority of pedographic inquiries deal exclusively with human subjects, the examples detailed in this instruction guide originate from chimpanzees displaying quadrupedal knuckle-walking strides. The inclusion of a primate-oriented application serves to not only display the flexibility with which the P.I.M. Tool may be applied, but also to widen the range of processed information that may be extracted from the aforementioned source data. This guide will detail Importing and Visualization of the data, manipulation of the data including zeroing or isolating specific regions, and exportation of data in easily workable .csv files. This guide will be updated regularly as new versions and updates are released. If you have any questions, please feel free to email danegibbons@gmail.com or nthomp03@nyit.edu. Let's get to work!

2.

Starting the Program

As stated in the introduction, P.I.M. Tool (which will be referred to just as PIM) was developed in MATLAB on Windows 10. As of the latest version, in order to use PIM, MATLAB 2016 or later is required. The Image Processing Toolbox is also required. Because the program was created in a Windows environment, the file addresses are specified to the Windows operating system, and as of the latest release, may only be used in Windows. Later releases will address using the P.I.M. Tool on a Mac or Linux machine. This guide, along with PIM and its corresponding toolbox may be found at https://github.com/degibbons/PIM-Tool. Either clone the repository onto your local machine or download the ZIP file using the button located at the top right of the screen (Image 1).

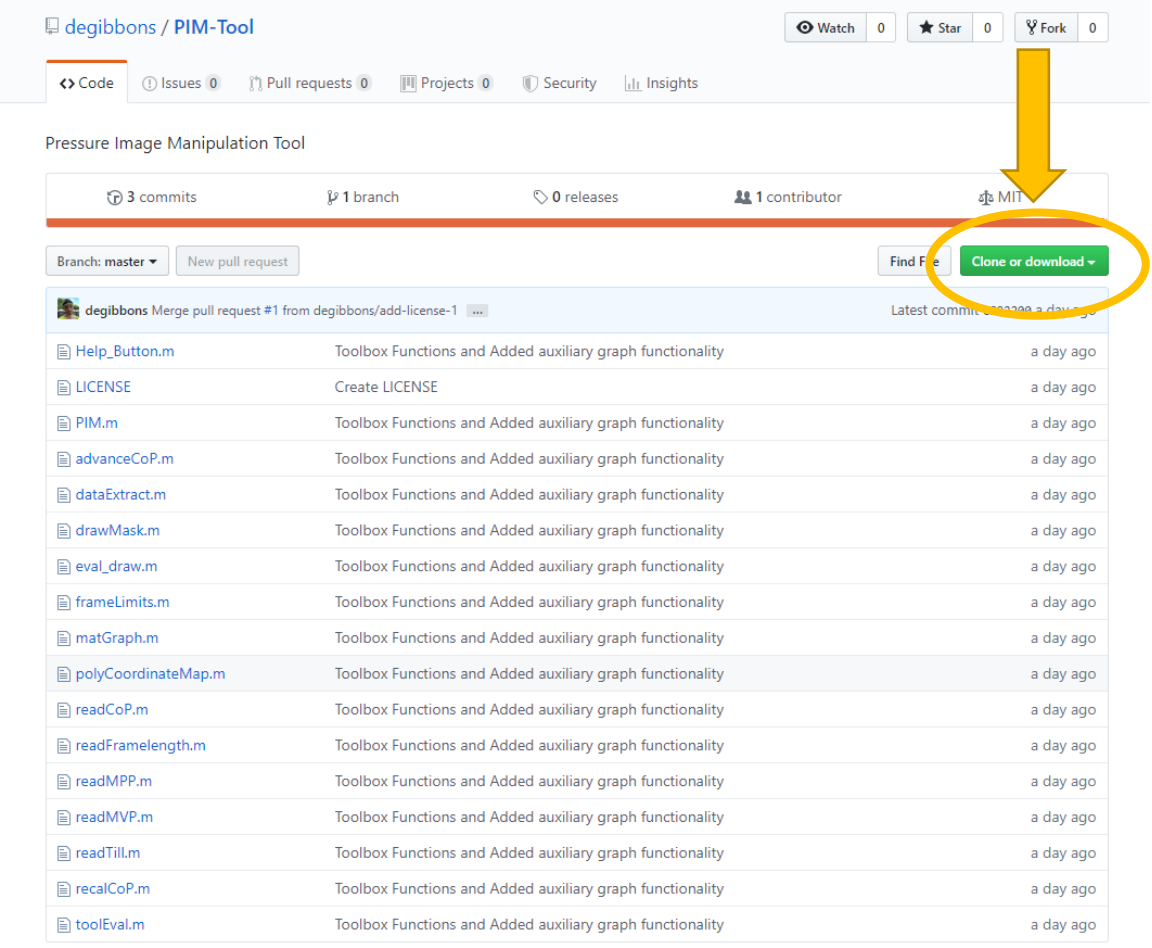

Image 1: Remote Repository Download Source

If you've chosen to download the ZIP folder, you'll see in your Downloads folder something similar to Image 2. Either use the Windows built in unzip/extract tool to unzip the folder or use an easily downloadable program such as 7-Zip to extract it, selecting either Extract All or Extract Here.

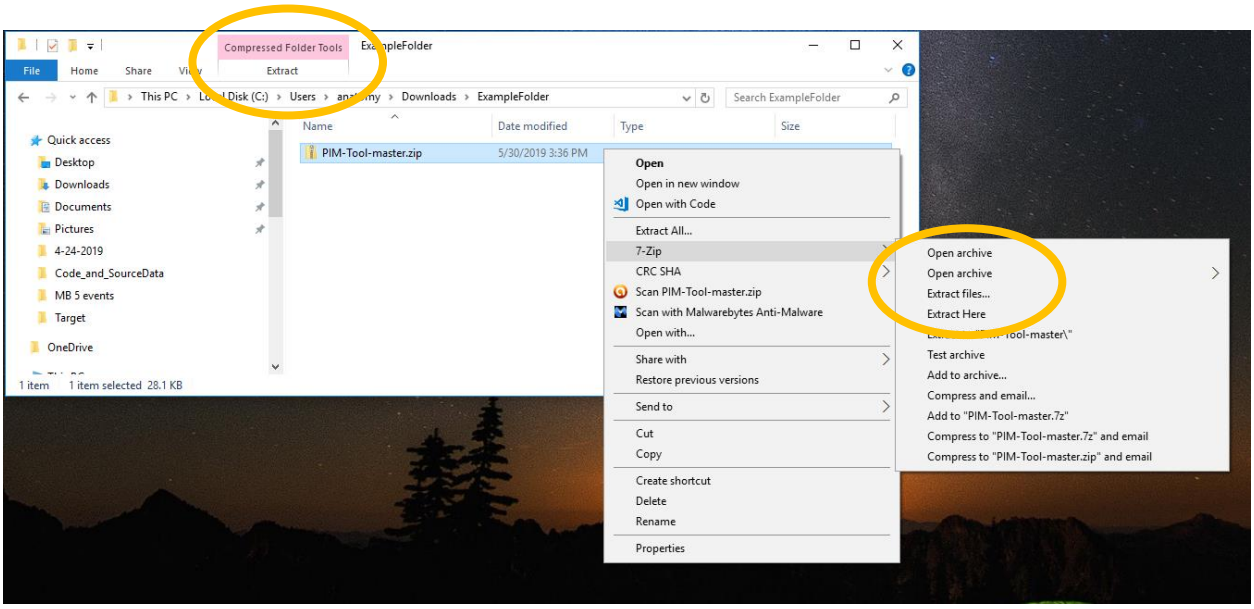

Image 2: Zip File Extraction

After extracting the PIM-Tool-master folder, you'll see something similar to Image 3. Inside is the toolbox required for and containing PIM.

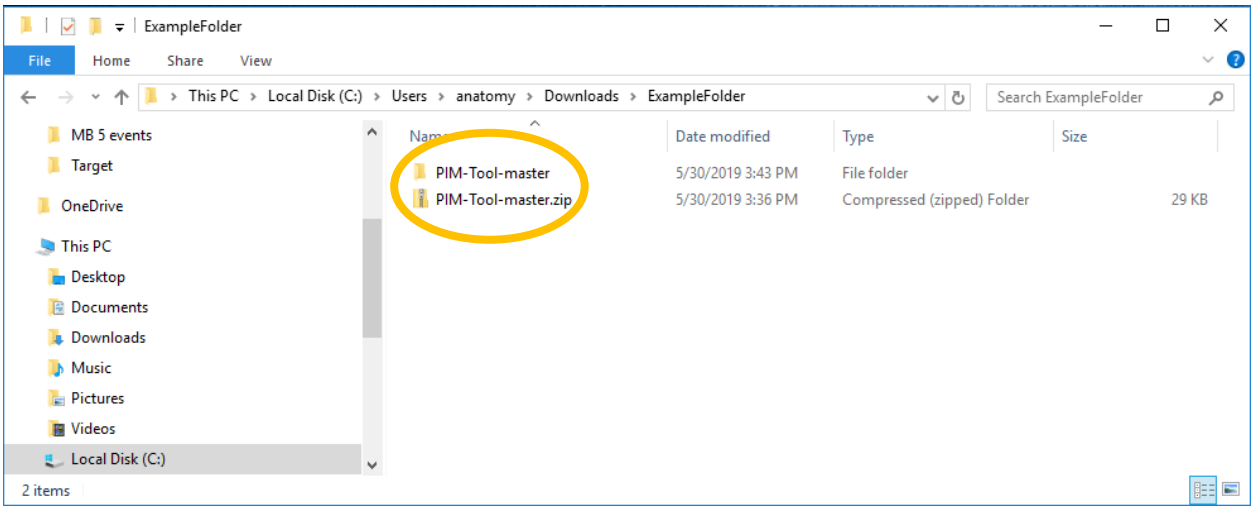

Image 3: Unzipped File Folder

After opening MATLAB, navigate to and open up the toolbox using the directory navigation buttons highlighted in Image 4. You can also copy and paste the entire directory address into the address bar towards the top of MATLAB.

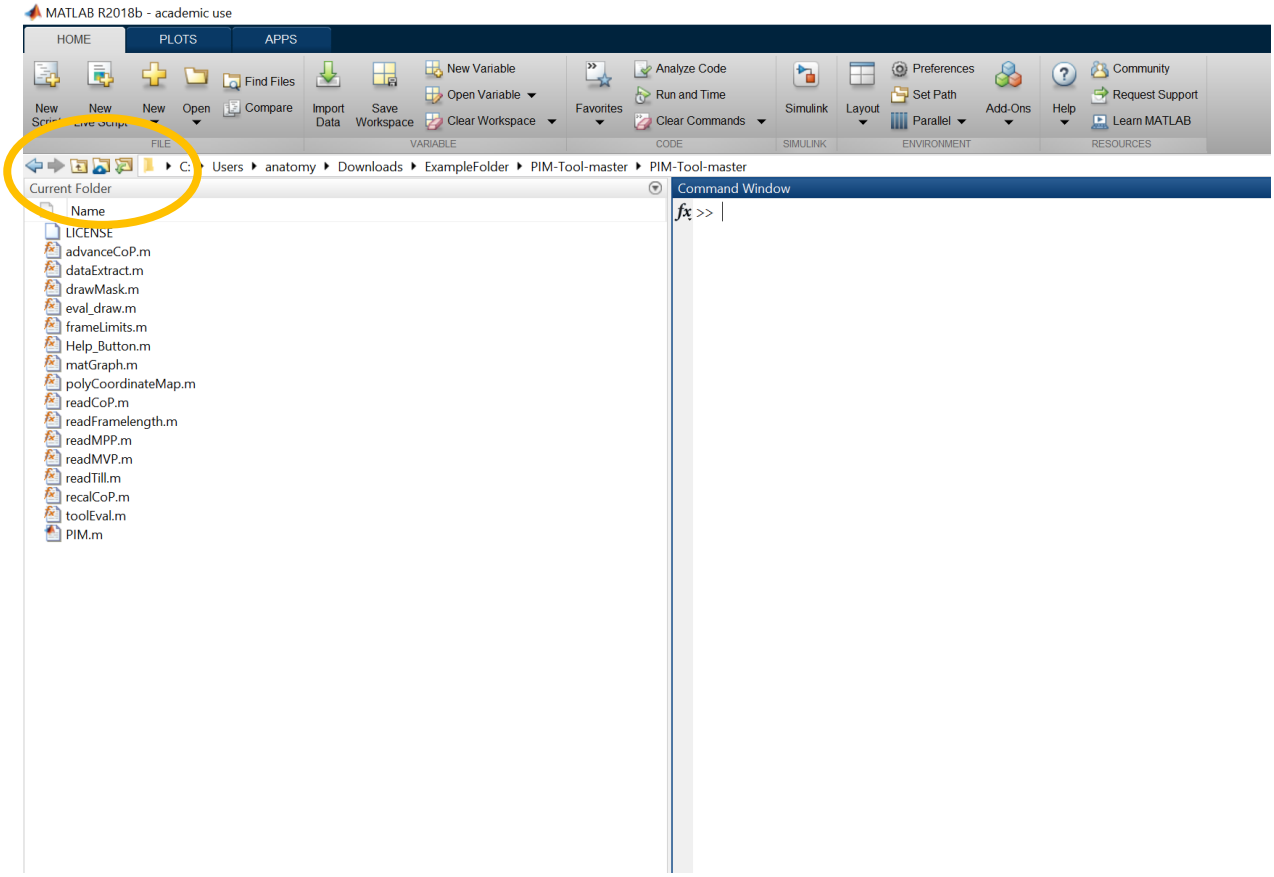

Image 4: Opening the toolbox in MATLAB

You may explore the source code, but unless you are fairly confident in the changes you are making or have a copy of the files readily available, PLEASE DON'T EDIT THE SOURCE CODE. Any changes, errors, or problems are encouraged to be emailed directly to the authors so the appropriate changes and patches may be implemented. From here, to run PIM, simply either type the word *PIM* into the Command Window and hit Enter, or select the PIM.m file from the file directory to the left and hit F9. The GUI should load up and look similar to Image 5.

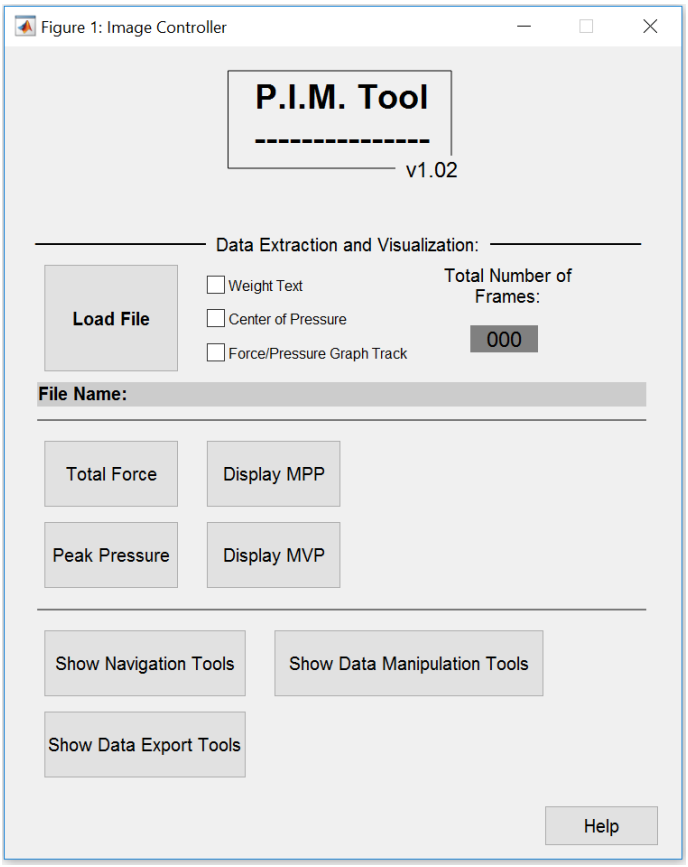

Image 5: Basic P.I.M. Graphic User Interface

That's it! Chapter 2 will address loading the file in to PIM so you can immediately get to work.

3.

Load a File

Now that you've got the PIM user interface up, it's worth noting a few things before we proceed. First, the version number is located underneath the title. Please make sure you have the latest version available on your machine. Second, only the Load File button and the Help Button are functional to begin with. All other buttons, check boxes, etc. may be clicked but there will be no action carried out. The further you progress, the more functionality that will be unlocked. There are processes that may only be applied once a procedure has been carried out or another button has been pressed, and as such, will remain inoperable until such appropriate actions are fulfilled. Finally, the help button is only a basic reference guide to specific buttons or processes. For a more in depth and encompassing explanation to any question or inquiry you may have, please refer either back to this guide or contact danegibbons@gmail.com with your specific questions.

With those quick notes out of the way, we may proceed! Simply click the Load File button and a file selector box will open (Image 6). Navigate to the file you want to open, select it, and click Open. The raw data file you select should be in .txt format and look similar to Image 7 when opened outside MATLAB.

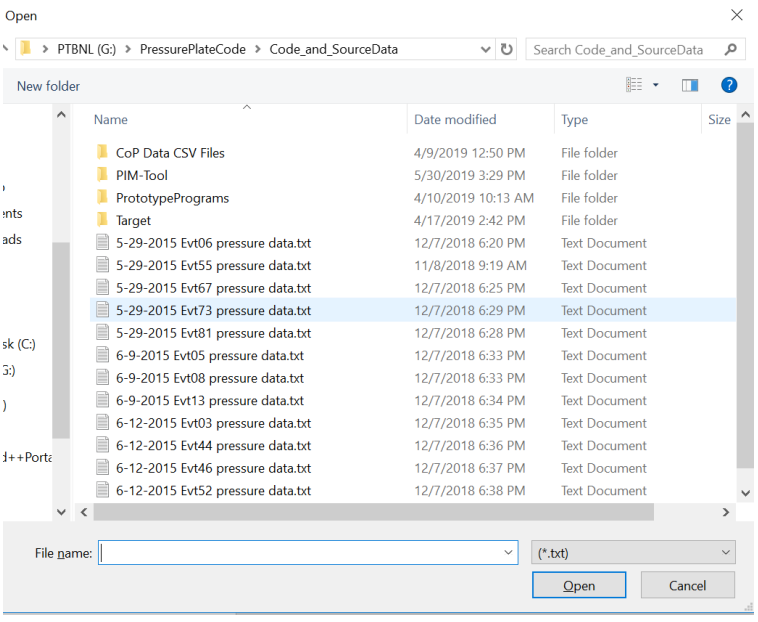

Image 6: Raw Data Selection

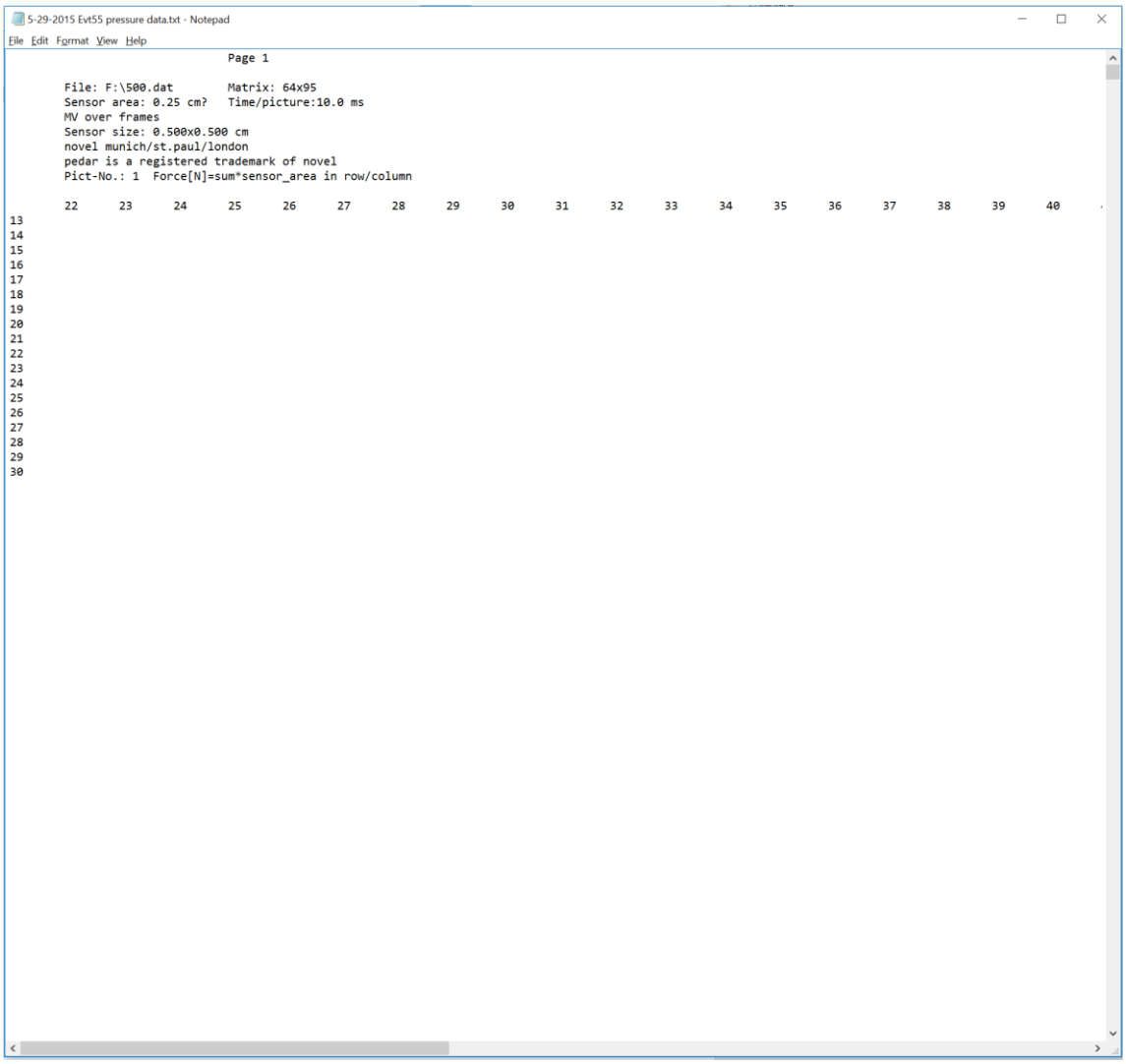

Image 7: Raw Data .txt file

After your image loads, you'll see something similar to Image 8: A heat map with a color axis on the right side (numbers in kPa). You may see a few sections with varying color weights depending on when contact with your pressure pad first begins. There will also be a black line that most likely snakes through your image with a red star at its beginning. This is the center of pressure path calculated from the entirety of your raw data. It spans across all frames with the current center of pressure for the current displayed frame indicated by the star. In the following chapters, we'll see how we can not only navigate to different frames, but hide, change, and export new center of pressure coordinates, and even place indicators on the display when something is no longer displayed.

NOTE: Each cell on the pressure pad is 1/2cm x 1/2cm. For ease of visualization, the MATLAB visualization displays each cell as a 1x1 box. Where the visual representation of the data is multiplied by 2 for graphing purposes, the coordinates printed in the terminal and produced by the export buttons display the correct non-multiplied values in cm.

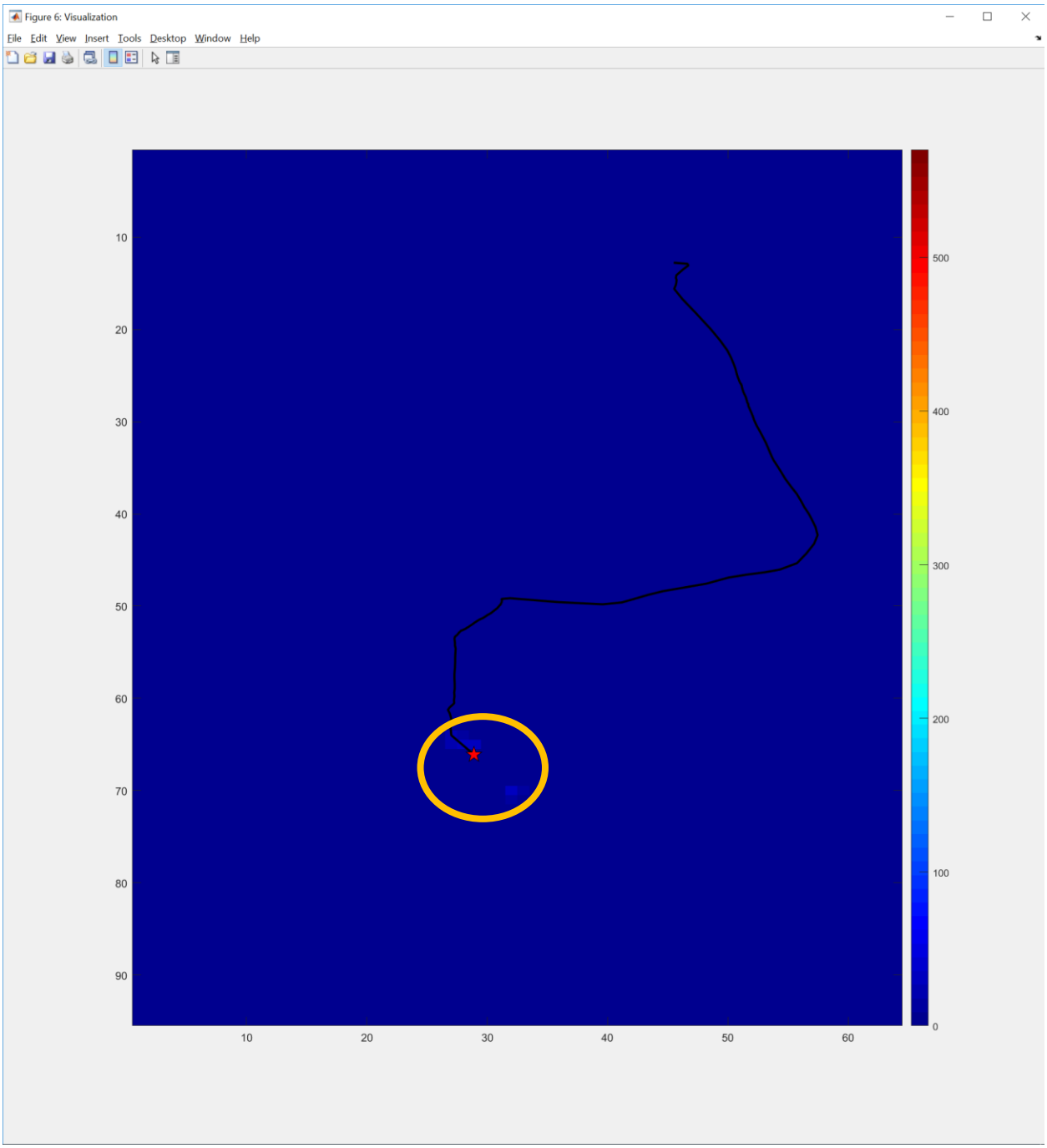

Image 8: First frame of pressure pad data. Contact points are circled.

4.

Visualization Options

Now that we've got our display window open, we can begin to explore our data. If we look back at our image controller, at the bottom of the Data Extraction and Visualization section, you'll see a grey bar displaying the name of the selected file (Image 9).

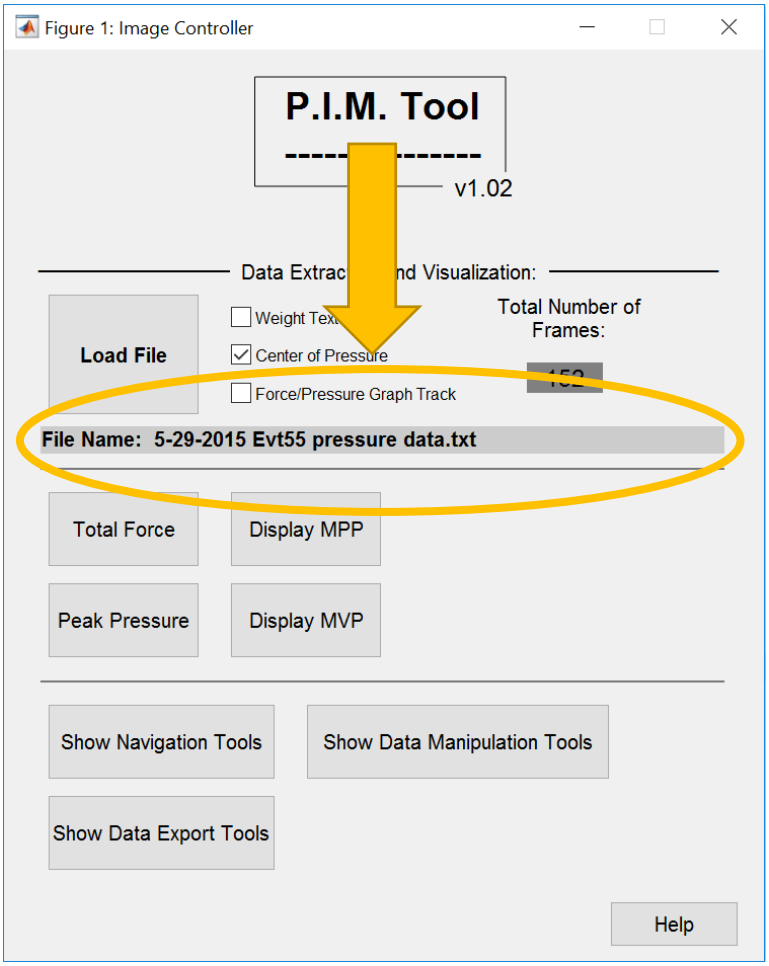

Image 9: The name of the current selected file.

Above this grey bar, you'll see three checkboxes: Weight Text, Center of Pressure, and Force/Pressure Graph Track (Image 10). The final check box option will be addressed after we

cover the Total Force and Peak Pressure graphs. For now, we'll address the Center of Pressure one. Selecting this option hides and displays the center of pressure pathway we saw graphed in Chapter 3 when we first loaded our file. This will also hide the star displaying the current frame center of pressure. When a file is first loaded, this option is set on by default.

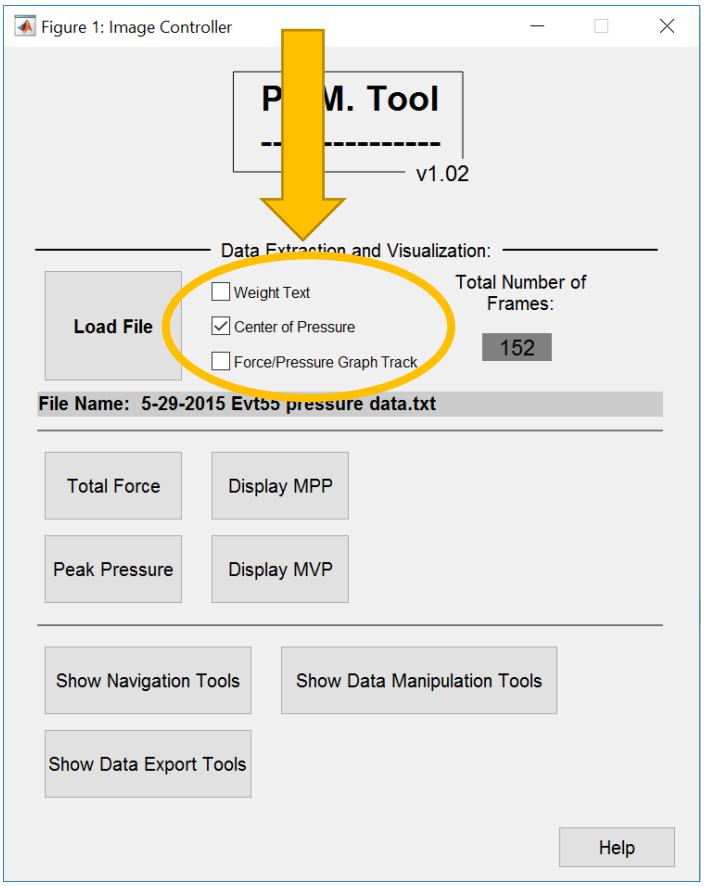

Image 10: Weight Text, Center of Pressure, and Force/Pressure Graph Track check box options.

The option above this is the Weight Text display. Selecting this option displays and hides the corresponding weight numbers associated with each pressure cell (Image 11). This may be used to compare cells to each other. It is highly recommended that you maximize your visualization window if you decide to make use of this option so the numbers are not cramped and are decidedly easier to read and discern. Selecting any other button or navigation action will automatically turn this option off due to the high amount of processing power required to plot, recalculate, and replot, these numbers with each action. This is purely for speed purposes, as the Weight Text option should only be used to compare pressure cells within a single frame.

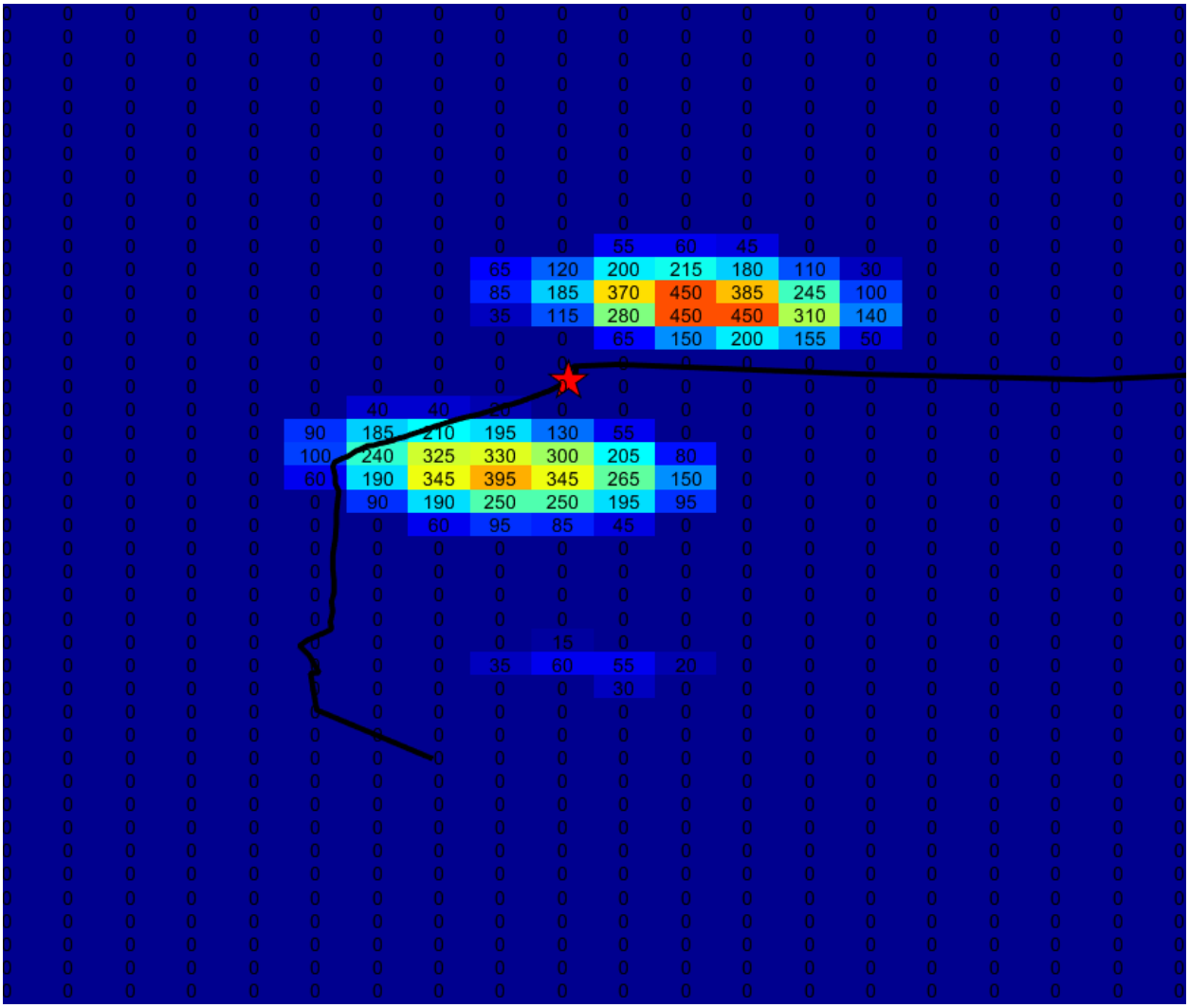

Image 11: Weight Text turned on for a single frame.

When not using the weight text option, it is highly recommended to keep the Visualization window docked to either side of your desktop so the visual representation is more representative of the original pressure pad (Image 12). With it docked to one side, it is longer than it is wide, and the axes are properly visualized. You'll also have room for the Image Controller and any other tool options that pop up that we'll explore later. On a Windows machine, to dock it to either side of the desktop, simply select the Visualization window, hold down the Windows Key, and hit the right or left arrows on your keyboard.

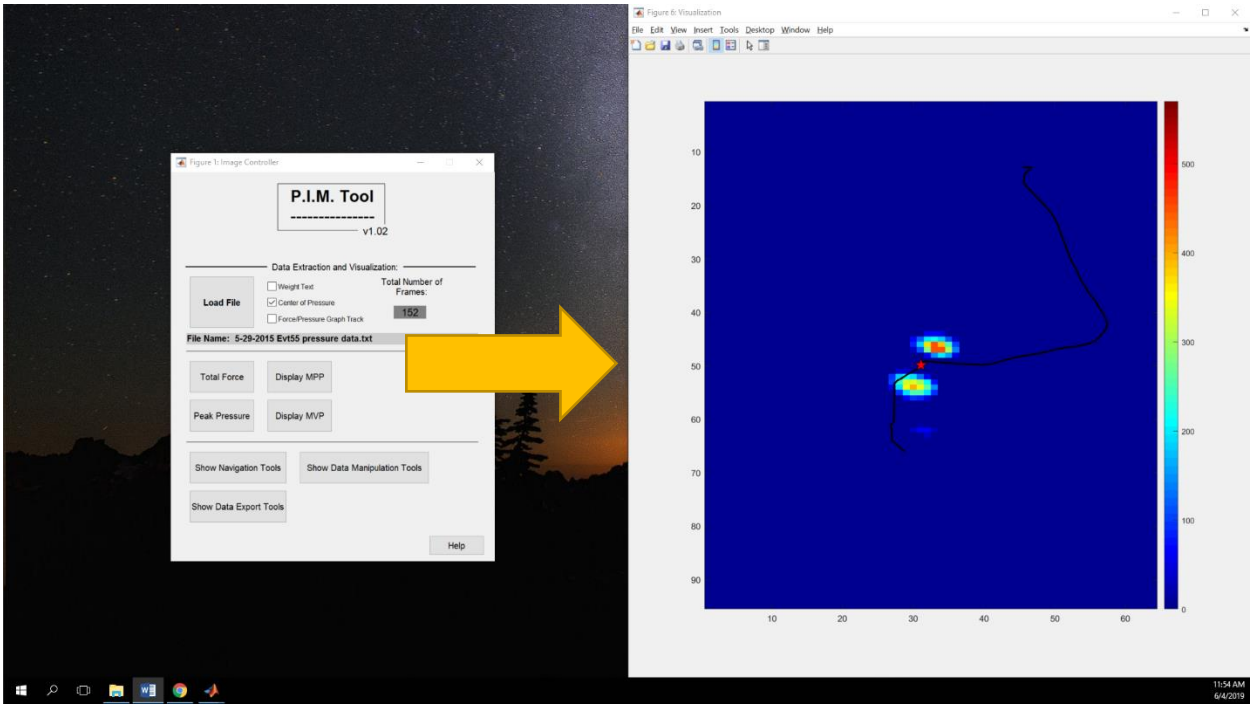

Image 12: Visualization window docked to the right.

Next to the check boxes, you'll also see a text box labeled Total Number of Frames (Image 13). After loading a raw data file in, the total number of frames detected in the .txt file will be displayed here. This should be used as a reference when navigating between frames and choosing between what frames a selected center of pressure should be calculated, both operations we will cover in later chapters.

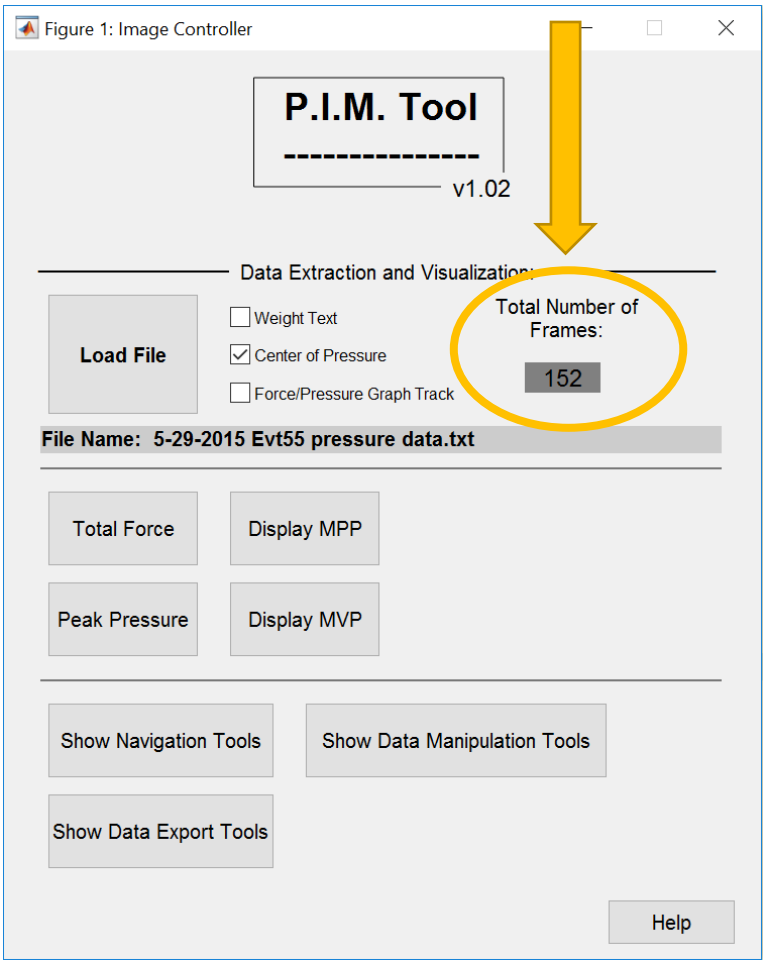

Image 13: The total number of frames displayed.

5.

Total Force & Peak Pressure Graphs

Below the first section of the Image Controller, you'll see four buttons: Total Force, Peak Pressure, Display MPP, and Display MVP (Images 14 &15). The first two, Total Force and Peak Pressure, display the Peak Pressure and Total Force amounts across all frames. Total Force is graphed in newtons where Peak Pressure is graphed in kPa (Image 16 & 17).

NOTE:

$$N = \frac{0.25 \cdot \sum(kPa)}{10}$$

The last check box option mentioned above, Force/Pressure Graph Track, displays a star along both graphs at the exact frame graphed in the Visualization window. While navigating between frames, the star will move along the graph accordingly. It is also useful to note that these graphs can and will be changed using techniques learned in the Data Manipulation Tools chapter.

Another thing worthy of noting is these graphs may be saved and exported using the File > Save As or File > Print… options using the header bar at the top of each graph. Tools > Data Cursor will allow you to trace specific points along the graph by clicking in specific locations. A box with the corresponding X and Y values will be displayed (Image 18). To delete these boxes/points, right click them and select Delete Current/All Data Tip(s), or left click them and hit the delete button on your keyboard. Zooming and panning around each graph are also possible by selecting these in the Tools section from the header bar.

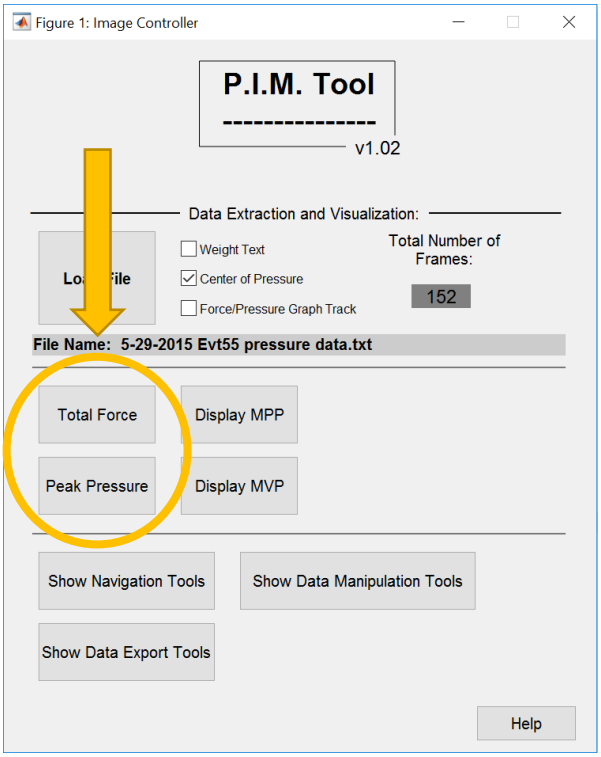

Image 14: Total Force and Peak Pressure display buttons.

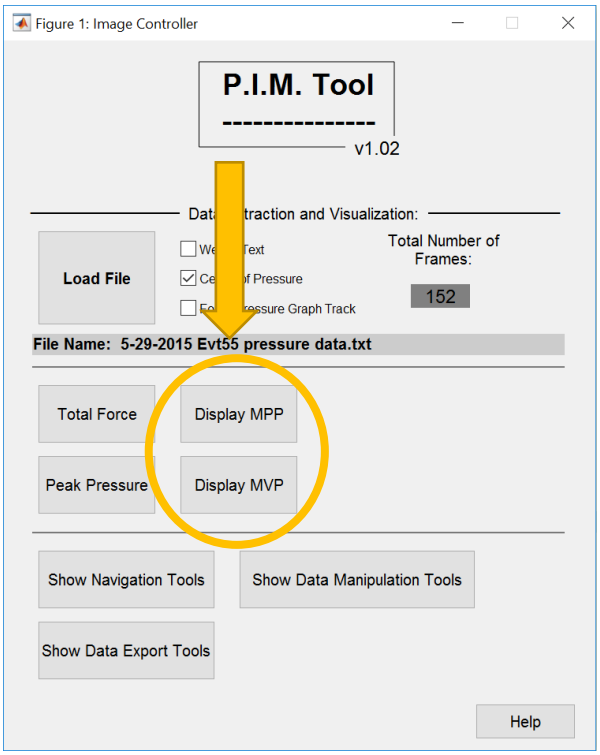

Image 15: Display MPP and Display MVP buttons.

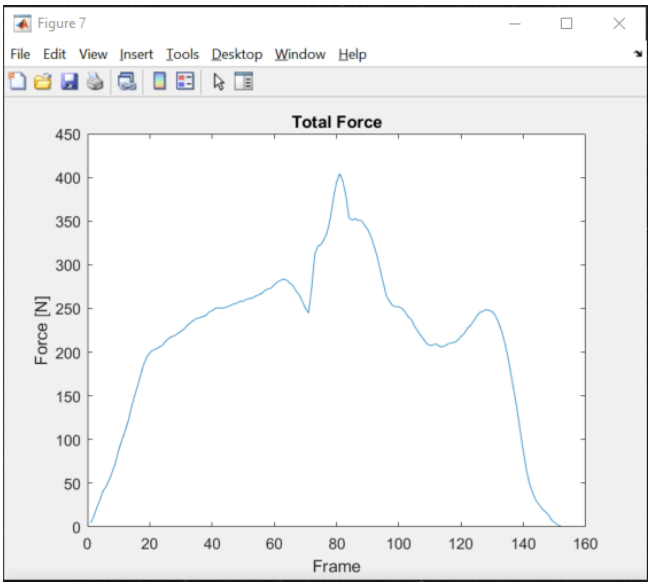

Image 16: Total Force Graph.

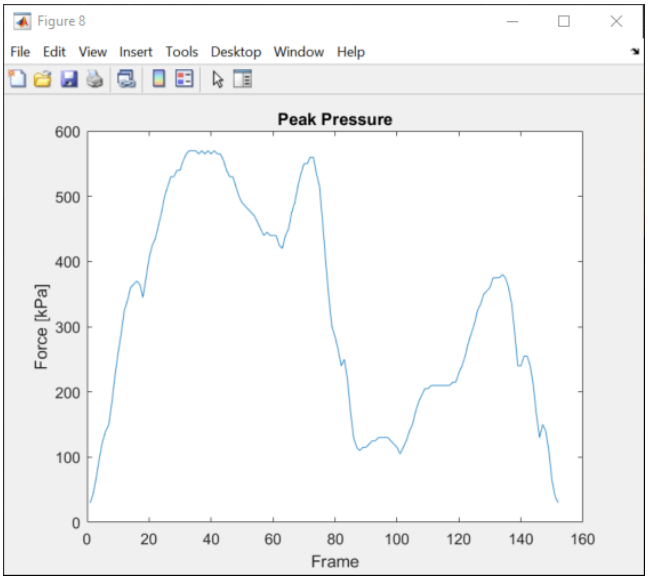

Image 17: Peak Pressure Graph.

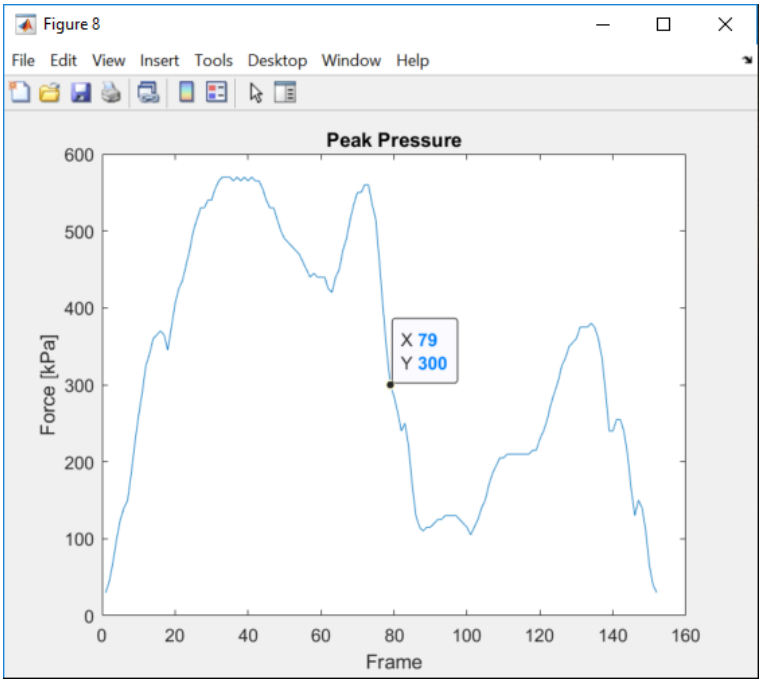

Image 18: The data cursor tool in use.

6.

Display MPP and MVP

The remaining two buttons, as shown in Image 15, are Display MPP and Display MVP. MPP stands for Maximum Pressure Picture where MVP stands for Mean Value Pressure. The MPP displays the maximum pressure across all frames where the MVP graphs the average across all frames. Both of these buttons will graph their corresponding weight graphs on the Visualization window (Images 19 & 20).

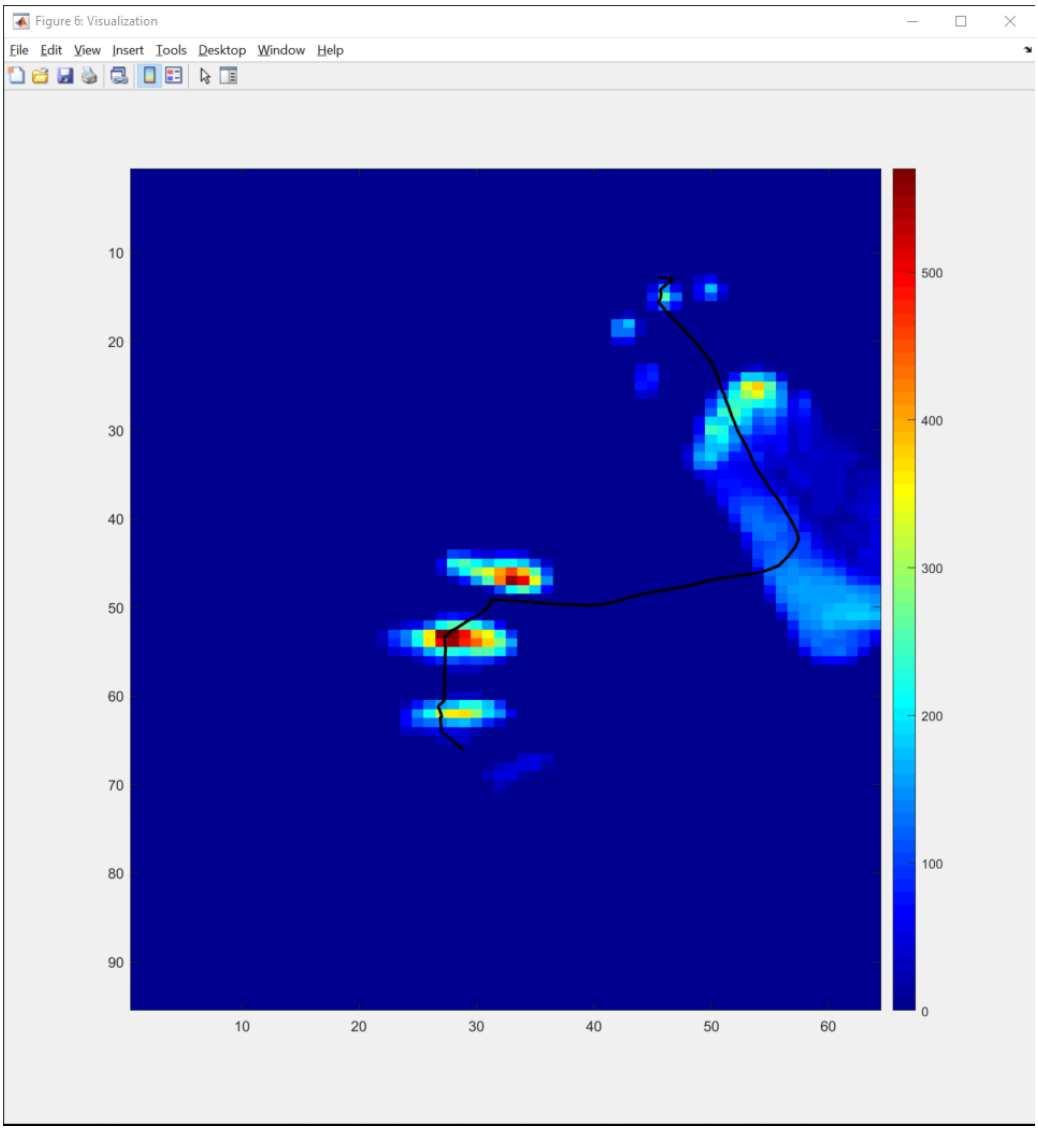

Image 19: Maximum Pressure Picture

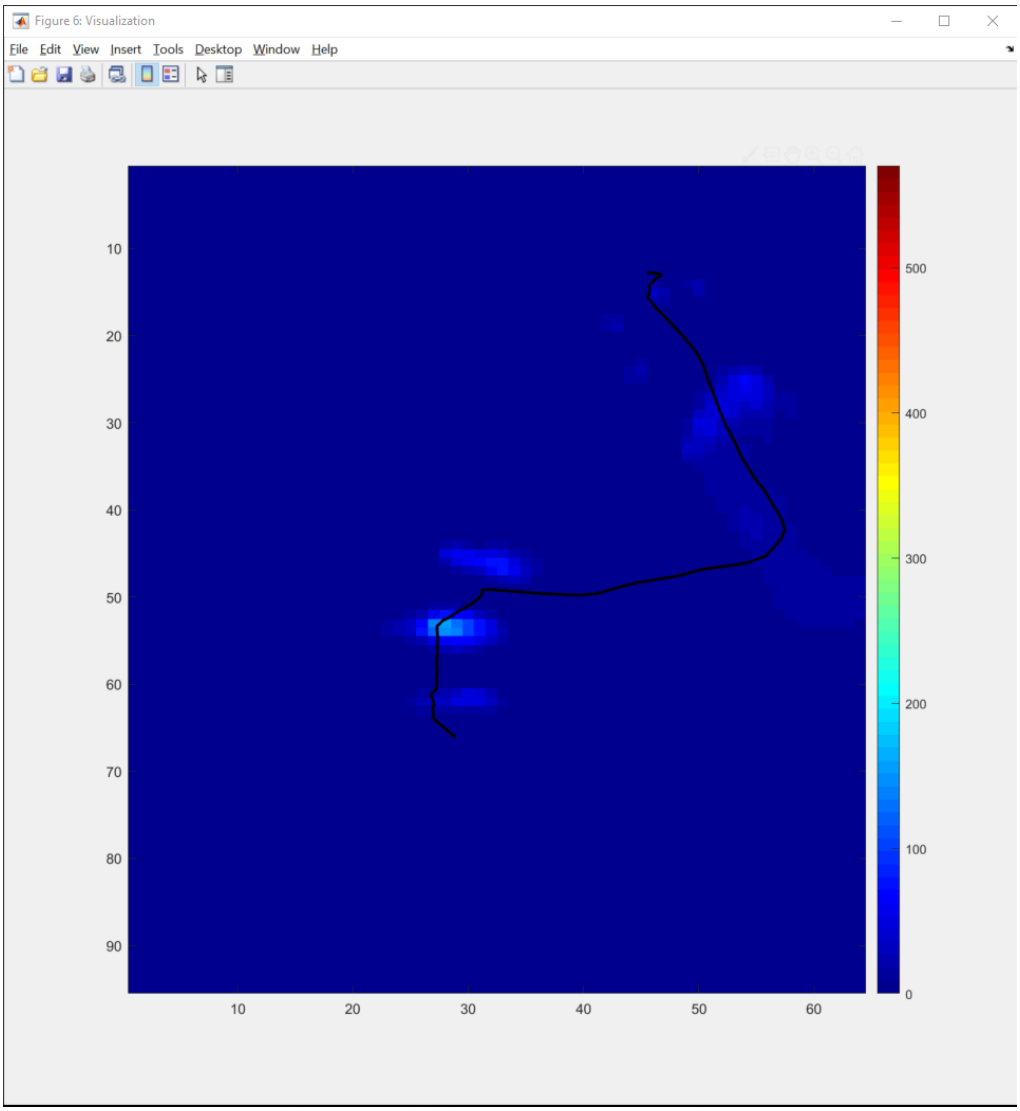

Image 20: Mean Value Pressure

Both of these graphs can and should be used for data manipulation purposes and reference. Like the Total Force and Peak Pressure graphs, these are also capable of Panning and Zooming using the corresponding options from the Tools menu at the top of the graph. Do keep in mind however, that when viewing either one of these graphs, because they do not represent a single instance of time, the user cannot navigate using the arrow keys, as will be demonstrated in the next chapter.

7.

Navigation Tools

In order to navigate between frames, we'll need to use the Navigation Tools. To show these tools, hit the Show Navigation Tools button in the third section of the Image Controller (Image 21).

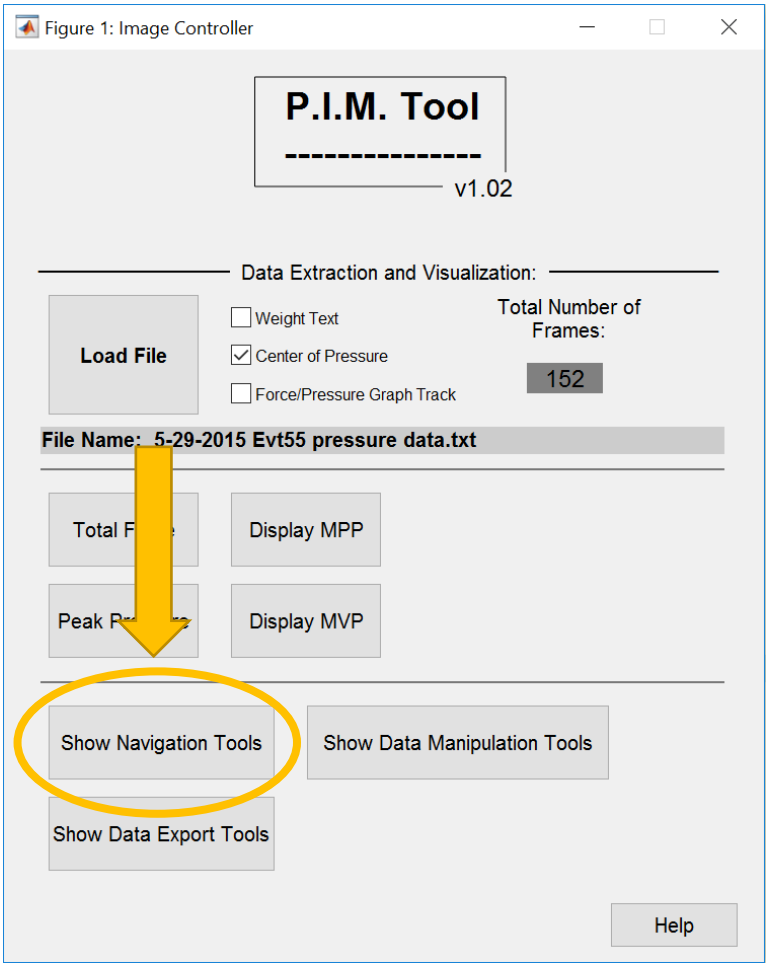

Image 21: Show Navigation Tools Button

A smaller window should open up that looks like Image 22. Each button is described below:

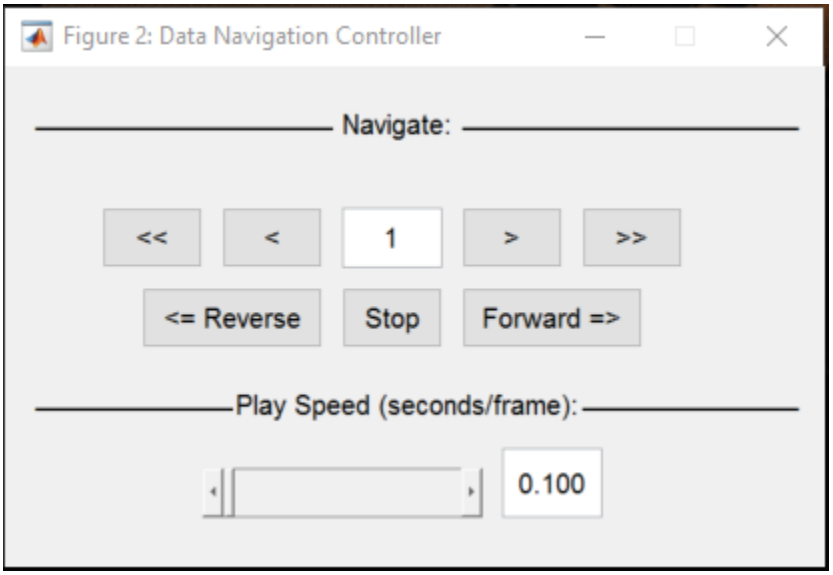

Image 22: The Data Navigation Controller

<< : Changes the displayed frame to the first frame.

< : Decrements the displayed frame by 1. Does not go beyond the first frame.

[65] : Change the displayed frame to the desired frame. Enter the desired frame number and hit enter. This will change when the other buttons are selected so as to display the current frame.

> : Increments the displayed frame by 1. Does not go beyond the last frame.

>> : Changes the displayed frame to the last frame, indicated by the Total Number of Frames box on the Image Controller.

<= *Reverse* : Consecutively decrements the frame number using the play speed displayed below.

Stop : Stop the Reverse or Forward processes while they are preceding.

Forward => : Consecutively increment the frame number using the play speed displayed below.

The scroll bar is used for adjusting the seconds per frame time limit before Reverse or Forward changes to the next frame.

The edit box next to the scroll bar is used to manually alter the seconds/frame time limit.

The speed may be adjusted from 0.100 seconds/frame to 1.000 seconds/frame.

NOTE: If the Visualization Window is selected, the arrow keys on the keyboard (Left and Right) may be used to navigate between frames as well. However, there is a current glitch that, when the buttons are hit repeatedly in quick succession, the focus switches to the MATLAB IDE. To avoid this, simply hold down the keyboard button or use the buttons on the Navigation Controller window.

As mentioned in the previous chapter, if the Display MPP or Display MVP buttons are selected, you will no longer be looking at a specific frame, but rather a general summary of data over time in a single graphic. After either of these buttons are hit, your Navigation Controller will look like Image 23. To shift back to single frame visualization, either simply select the Return to Single Frame button which will automatically re-graph the first frame, or enter your desired frame into the Edit Box below the button and strike the Enter button.

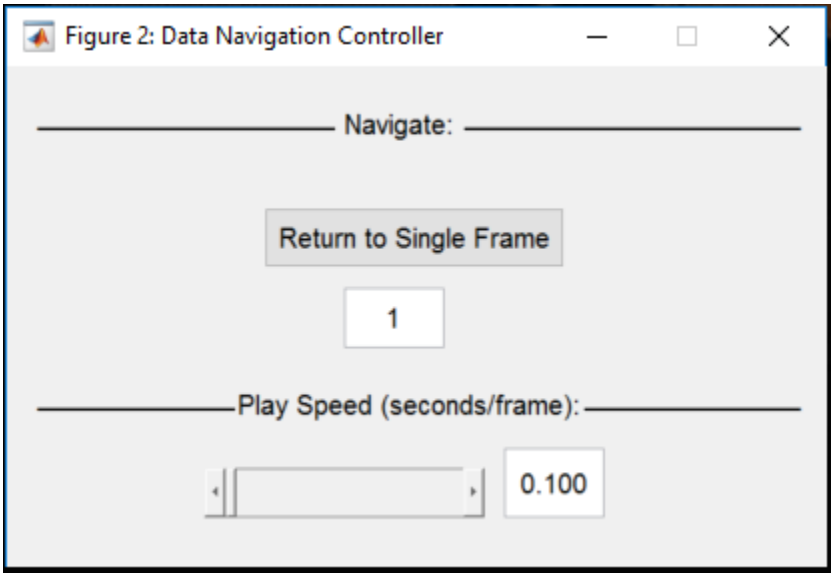

Image 23: Navigation Controller while MPP or MVP is displayed.

8.

Data Manipulation Tools

To open the Data Manipulation Tools, hit the Show Data Manipulation Tools button on the Image Controller (Image 24).

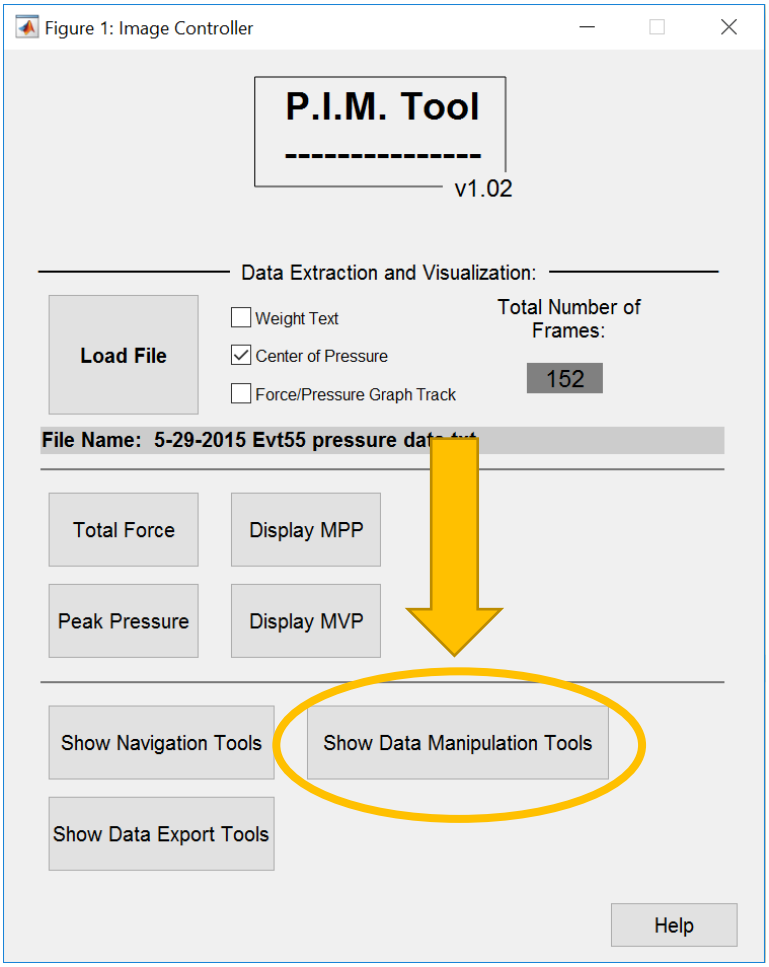

Image 24: Show Data Manipulation Tools Button.

A smaller window should open up that looks like Image 25.

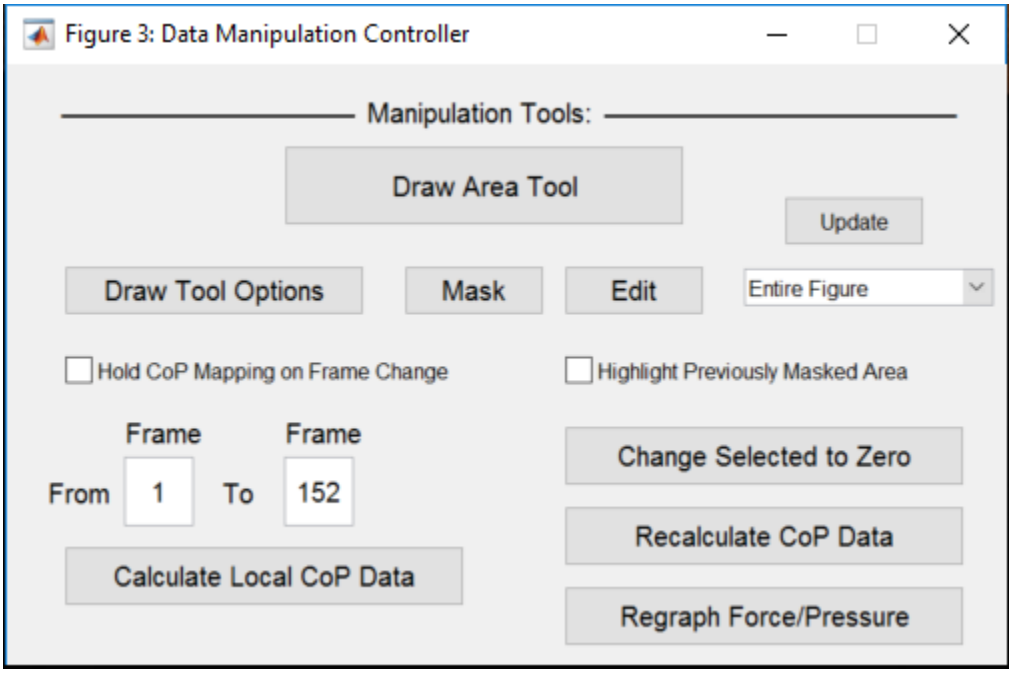

Image 25: Data Manipulation Controller.

Each button, checkbox, drop down list, and edit box with a short description will be displayed below.

Draw Area Tool: This button will be selected when an individual wants to encircle, mark, or zero out a region on the Visualization Window. These tools work solely on the Visualization window and as such, will not work on the Total Force or Peak Pressure graphs. They will however, and in fact are intended to work on the MPP and MVP graphs. The different option types the Draw Area Tool may employ are selectable in the Draw Tool Options. After the desired options are selected, the Draw Area Tool is selected and the focus is shifted to the Visualization window, where the user may perform a number of tasks detailed below.

Draw Tool Options: This button will bring up a tertiary window that looks like Image 26. To the left will be 5 different marker options for drawing masks. To the right will be two check boxes and two buttons. After selecting the desired mask type and hitting apply, the user then selects the Draw Area Tool. Each of the 5 draw methods in Image 27 are capable of being used. A range of options are provided for speed or greater control over the defined area.

- *Straight Line* – Draw straight lines to form an n-sided polygon. Last vertex must lay on top of the first. In order to ensure polygon is closed, when placing cursor over the first vertex in the polygon, your cursor should become a circle, closing the polygon and exiting the drawing mode. This is the default mode.
- *Free Hand* – This mode is similar to Straight Line, except you have greater control over the vertex placement. Hold the left mouse button down and drag to encircle an area. Letting go of the mouse button will draw a straight line from the release point vertex to the first vertex, closing off the polygon and ending the draw mode.
- *Rectangle* – This mode is simple and meant for speed, but sacrifices control. Simply click and drag to place and resize the rectangle around the chosen area. Letting go of the mouse ends the draw mode.
- *Ellipse* – Very similar to Rectangle, except it draws a curved ellipse instead.
- *Point Marker* – The point marker is used to place points at specified places around the Visualization window for either markers indicating boundaries that may not be visible in the current or a later window, or to highlight a feature that may not be capable of being highlighted with the previous four options. This option is NOT used to create masks. In order to escape draw mode, make sure the Visualization Window is selected and hit the Escape button on your keyboard. There is a small glitch where changing frames in the middle of placing these points may cause the markers themselves to behave irregularly (e.g. the visibility of the points may be switched off without etching the point into the graph below). PLEASE be sure to hit Esc before continuing with any other operations or switching frames.

NOTE: The drawn shapes may overlap as is shown in Image 27. This is perfectly fine and can be used for masking so long as other pressure cells not in the intended area are not encircled. The shapes themselves as well as their own singular vertices may be adjusted before being officially masked.

NOTE: The Point Marker option is still buggy. If there is an issue with the display or behavior of the points and their placement, toggle on and off the Fix and Highlight Previously Masked Area checkboxes. If those don't clean up the problem, proceed one frame forward or backward. Most problems should be solved by any or all of the three previous mentioned methods. Any problems not solved should be addressed to Dan Gibbons via e-mail.

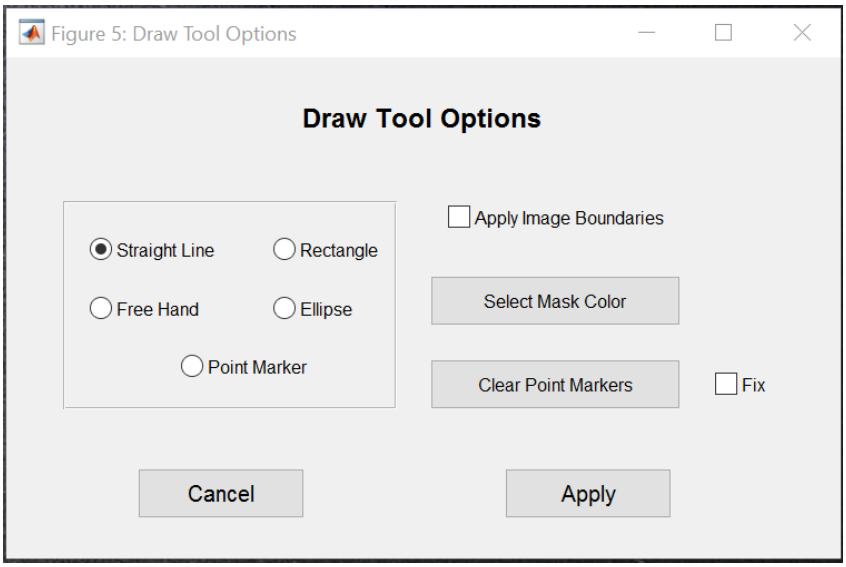

Image 26: Draw Tool Options Window.

- *Apply Image Boundaries* – Due to internal MATLAB graphing tendencies, the graph itself displays axes from 0.5 to 64.5 and 0.5 to 95.5. Given this slight shift, along with the tendency for pressure images to fall along and outside the given boundaries of the pressure pad, it is common to have the Draw Area Tool fall outside the given visual bounds of the current axes. If the Apply Image Boundaries box is checked, any vertices that fall out of the 0-64 and 0-95 range will be automatically shifted to inside the visual graph after exiting the Draw Mode.

- *Select Mask Color* – After drawing the encircling polygonal shapes to create the desired masks and exiting the Draw Mode, your shapes should look like Image 27. The Mask button (addressed later) is used to cement the mask positions and make the drawings themselves disappear. If the Highlight Previous Masked Area checkbox is selected (as described later), imprints of the masks will be etched into the graph. By default, MATLAB will assign a random color to the mask imprint. If a color is selected using the Select Mask Color button, all masks will display as this color. This can be useful if you need a specific masked region to be easily identifiable or visible. If the masked areas are displayed after selecting a color, uncheck, then recheck the Highlight Previously Masked Area checkbox to refresh the masks.

- *Clear Point Markers* – Selecting the Clear Point Markers button clears all masked Point Markers in the Visualization window. This is useful if you want a visual of only masked areas without the point markers visible.

- *Fix* – When the Fix checkbox is checked, the previously masked point markers are brought back to their state before they are masked. This way, they can then be moved or deleted individually if you don't want to clear all the point markers at once.

- *Apply and Cancel* – Selecting the Apply button seals in the settings you've selected and closes the Draw Tool Options Box. Selecting Cancel reverts the Draw Mode selection back to the previous selection and closes the box. The remaining options will stay selected. (This may change in future releases.)

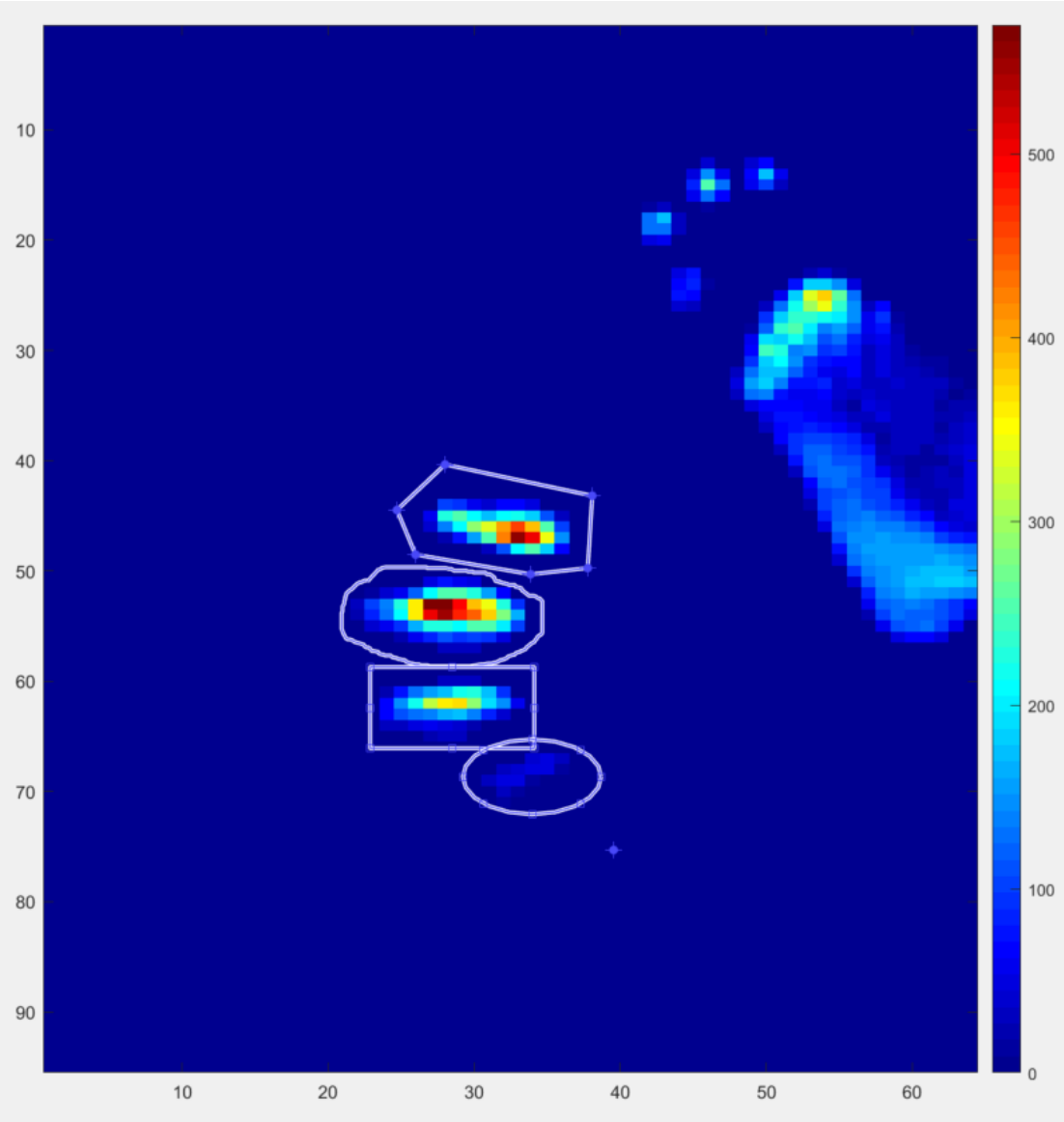

Image 27: Descending from the top, the 5 Draw Modes: Straight Line, Free Hand, Rectangle, Ellipse, and Point Marker.

Mask – The Mask button cements the position of the drawn polygons, hides the movable sides and vertices, then etches the shape into the graph beneath them. They will remain hidden until Highlight Previously Masked Area is checked. The masked areas are shown in Image 28.

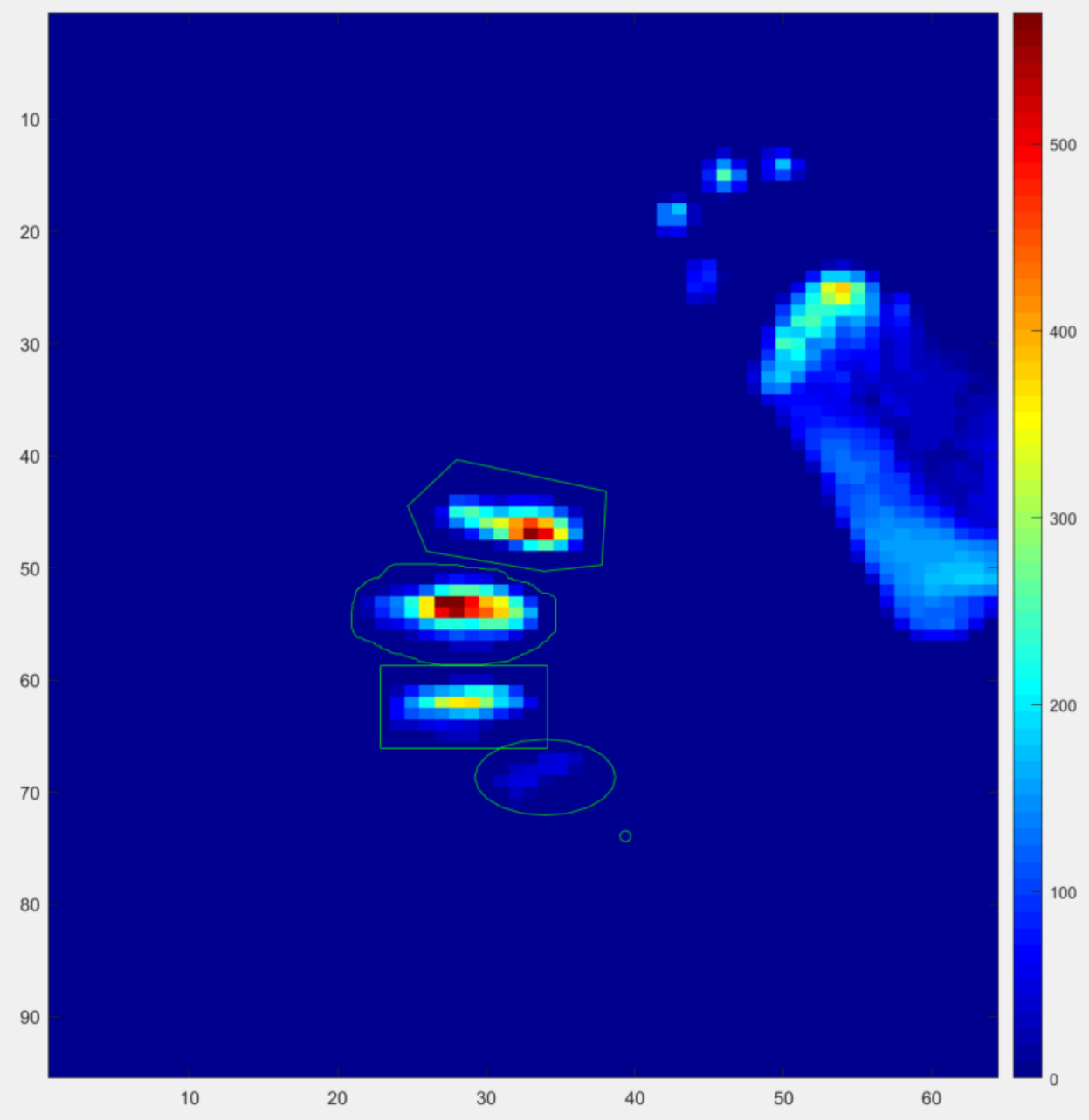

Image 28: The masked areas with Highlight Previously Masked Area checked. A nice green was selected with the Select Mask Color button. Notice there are no lines or vertices to accidentally move or shift.

Edit – The edit button brings the editable vertices and sides of the masked areas back to the foreground (as in Image 27). You can shift, resize, delete, or alter your masks in any way you desire. After your edits are complete, hit the Mask button, and the polygons will be immediately cemented again.

NOTE: If Highlight Previously Masked Area is checked when Edit is selected, the etched masks will remain while your edits are taking place. Even after the Mask button is hit, the old mask positions will remain. In order to apply the new changes visually, uncheck, then recheck the Highlight Previously Masked Area box to refresh the masks.

Dropdown Box – The Dropdown box displays each polygonal mask drawn with a number next to it corresponding to the order in which they were drawn (Image 29). The Entire Figure option refers to the entire frame as a whole. After a shape is selected, it may be used for a specific operation such as calculating its local center of pressure data. If you are unsure which shape corresponds to which number, after the Edit Button is selected, you can select a shape from the Dropdown box. The selected shape will be highlighted in pink (Image 30).

Update – When using the Edit button to edit your mask shapes, you may delete a shape. The Dropdown box however does not update automatically. In order to update the box to accurately reflect the available masks (and shift the numbers accordingly), after you are finished editing, select Mask, then select Update. The Dropdown box list should be updated accordingly.

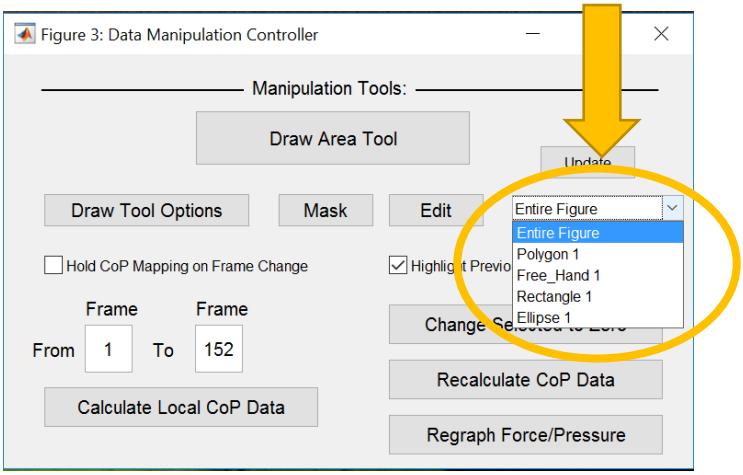

Image 29: The dropdown list according to the plot of Image 28.

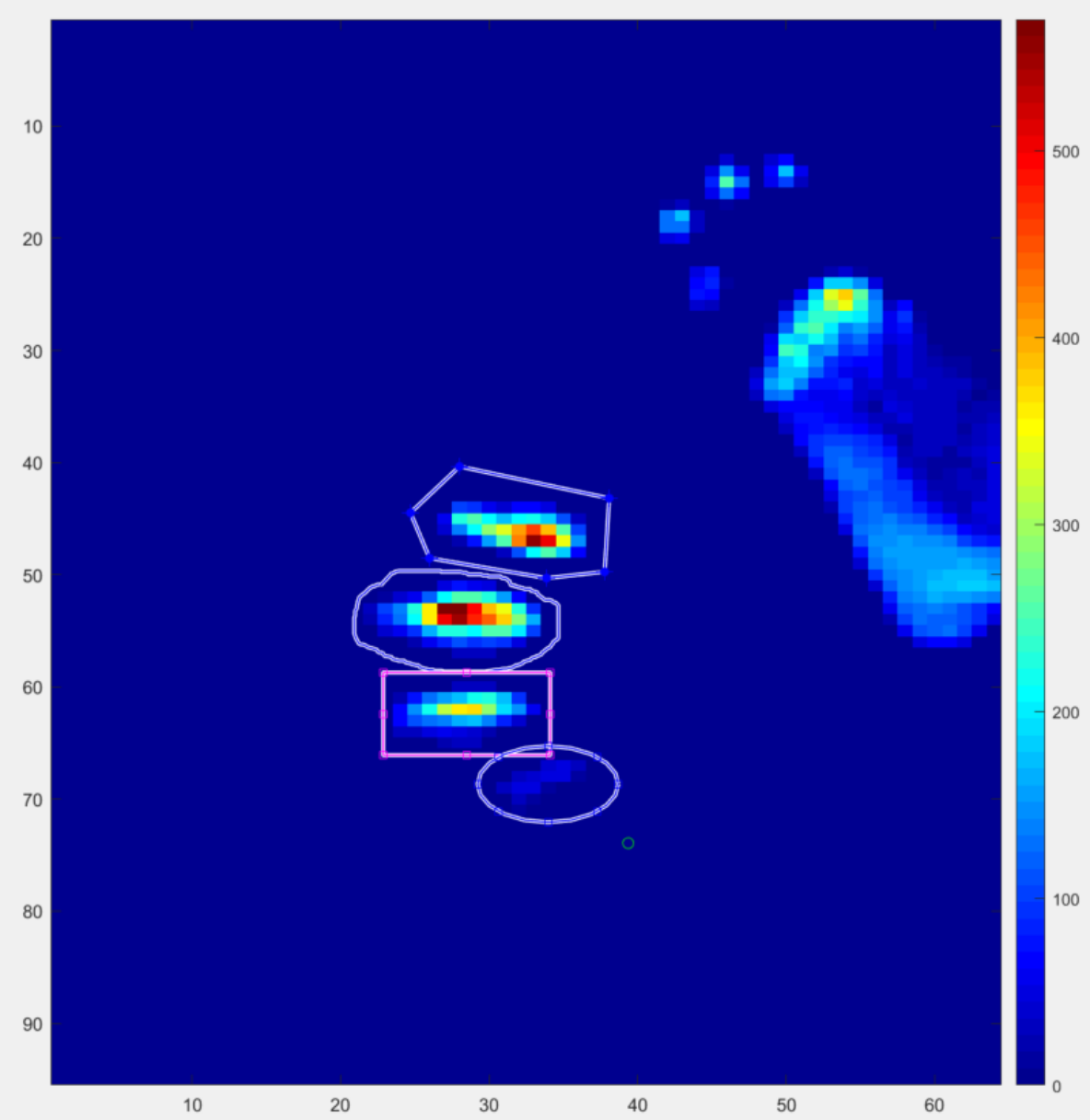

Image 30: Edit selected with Rectangle 1 selected from the Dropdown box (highlighted in pink).

Hold CoP Mapping on Frame Change – After calculating the local center of pressure data for (a) specific mask(s), a center of pressure path will be mapped out for the specific masked area on the heat map. However, changing the frame after this process will clear the graph of this center of pressure line. In order to keep the pathway graphed across frames and allow the current center of pressure to progress down the line visually, this checkbox should be checked.

Highlight Previously Masked Area – As mentioned previously, the Highlight Previously Masked Area checkbox is used to visually display the previously masked point markers on the heat map (Image 28). Uncheck and recheck this to refresh the mask shapes after editing.

Calculate Local CoP Data [Frame to Frame] – After selecting a specific mask from the Dropdown box and making sure everything is masked, you can hit the Calculate Local CoP Data button. It will calculate the center of pressure ONLY in the masked area over the allotted frames (Image 31). Above this button are two edit boxes with a pre-set frame range from frame 1 to whatever the ending frame of your data file is. These may be edited for further clarification. They will be displayed with their own corresponding center of pressure pathway and 6-pointed star for the center of pressure of the current frame. The numerical value of the force measurement and the coordinates at which the center of pressure for the current frame are located will be printed in the MATLAB IDE. Use the Hold CoP Mapping on Frame Change checkbox to keep the pathway and star graphed on frame change so the progression along the path may be observed.

Change Selected to Zero – After selecting a masked area from the Dropdown box, the pressure cells in the selected masked area may be turned to zero (Image 32 & 33). This is useful for isolating specific aspects of a pressure sequence without outside noise or artifacts interfering. This button is intended to be used with the Recalculate CoP Data button. This button will zero only between the indicated frames above the Calculate Local CoP button (Inclusive).

Recalculate CoP Data – After zeroing a specified masked region in the Visualization window, the center of pressure across all frames should change. In order to recalculate and re-graph this data, after having selected Change Selected to Zero, the Recalculate CoP Data button should be pressed. Image 34 displays an updated center of pressure path after the button is pressed.

Regraph Force/Pressure – Just like the center of pressure path, the Total Force and Peak Pressure graphs should also change after pressure data has been removed. After the Change Selected to Zero button has been pressed, the Regraph Force/Pressure button should be pressed. Image 35 & 36 show the newly graphed Total Force and Peak Pressure graphs. These may be compared to Images 16 and 17.

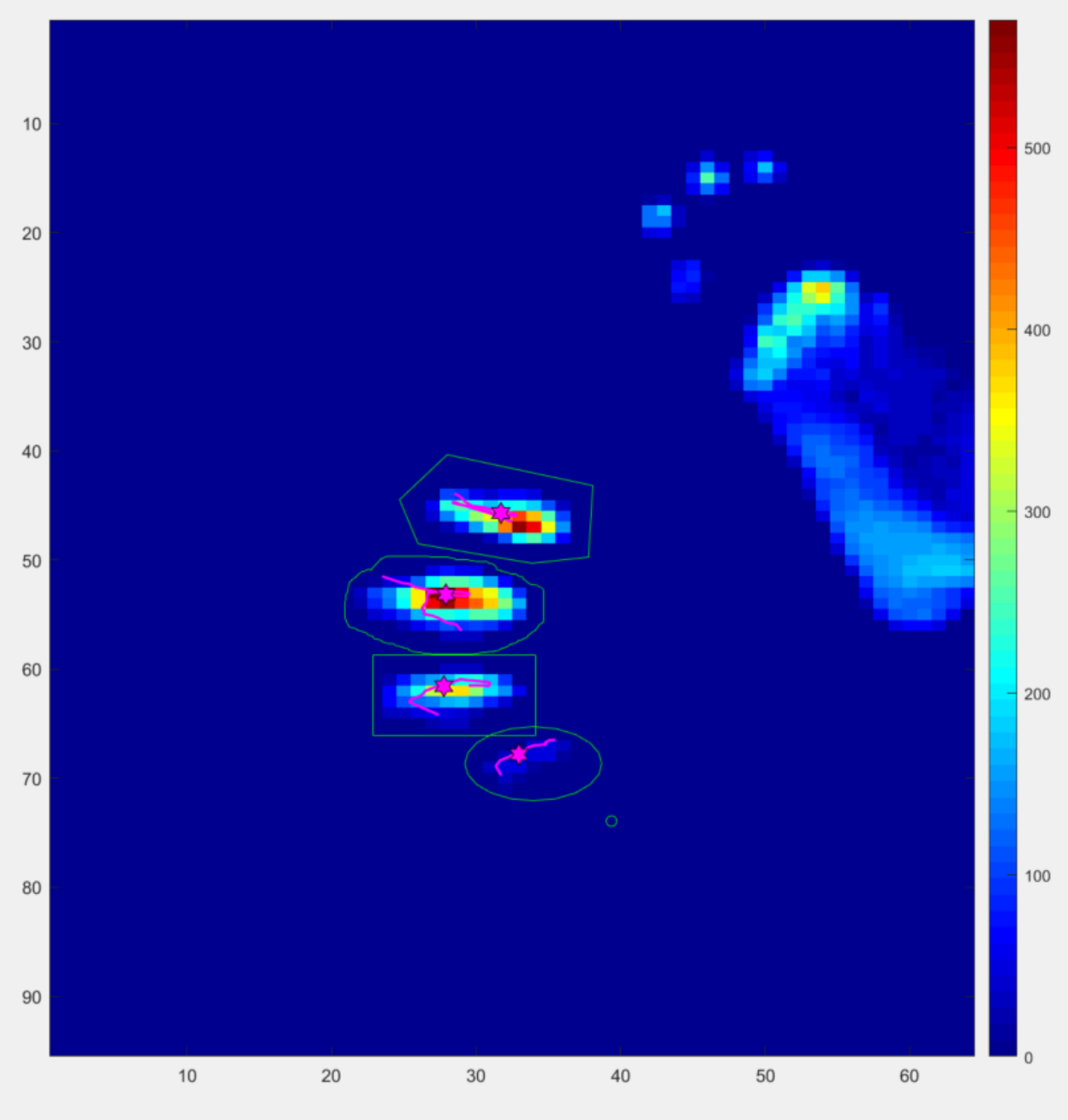

Image 31: The local CoP data paths calculated for each of the four masks (with masks present for ease of identification

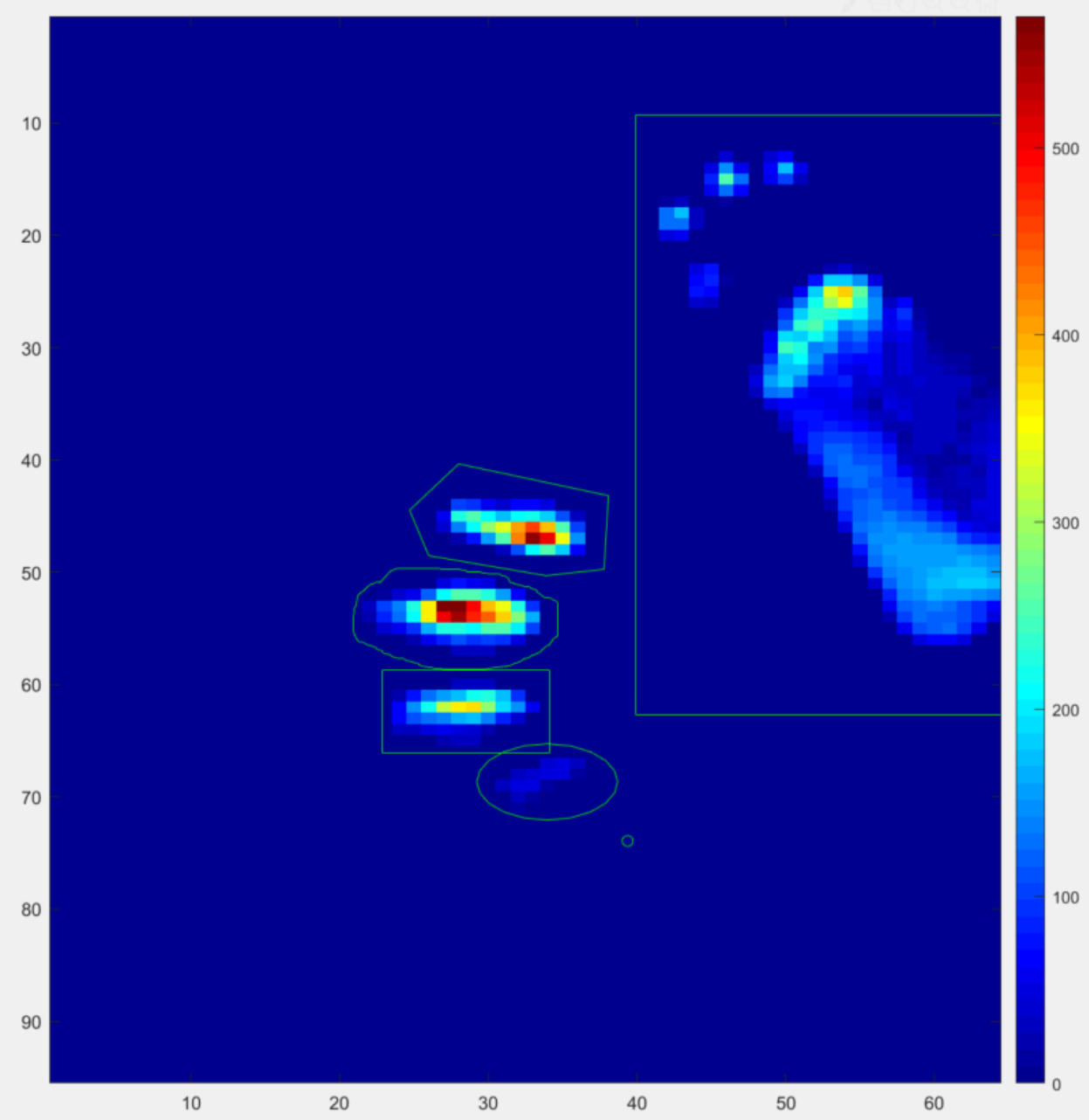

Image 32: Previous pressure image with the footprint now masked with a rectangle. Notice it continues past the bounds of the graph.

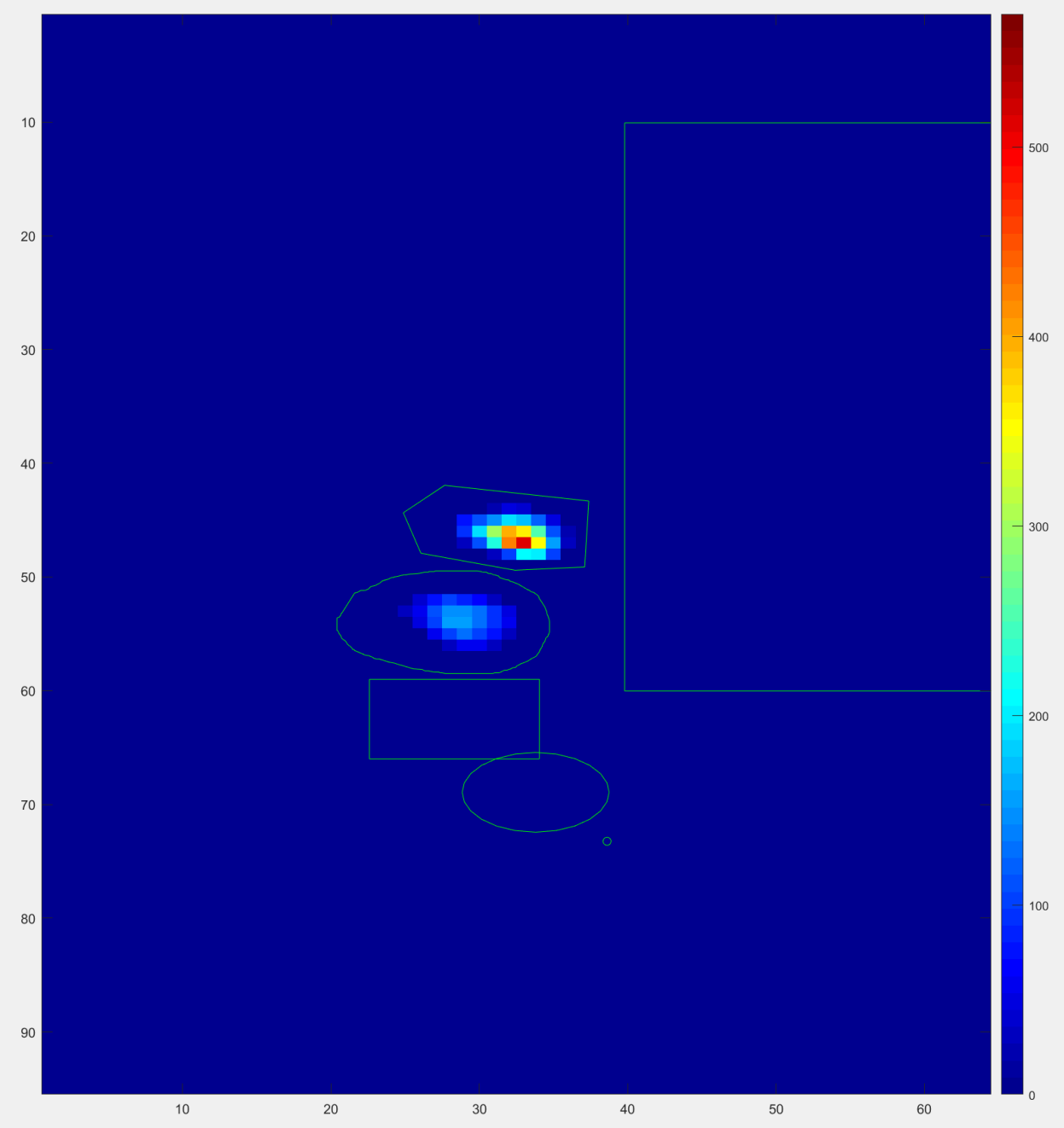

Image 33: A still of frame 75 out of 152. The foot pressure imprint masked on the right, typically shown at this point in time, is not visible after having been zeroed.

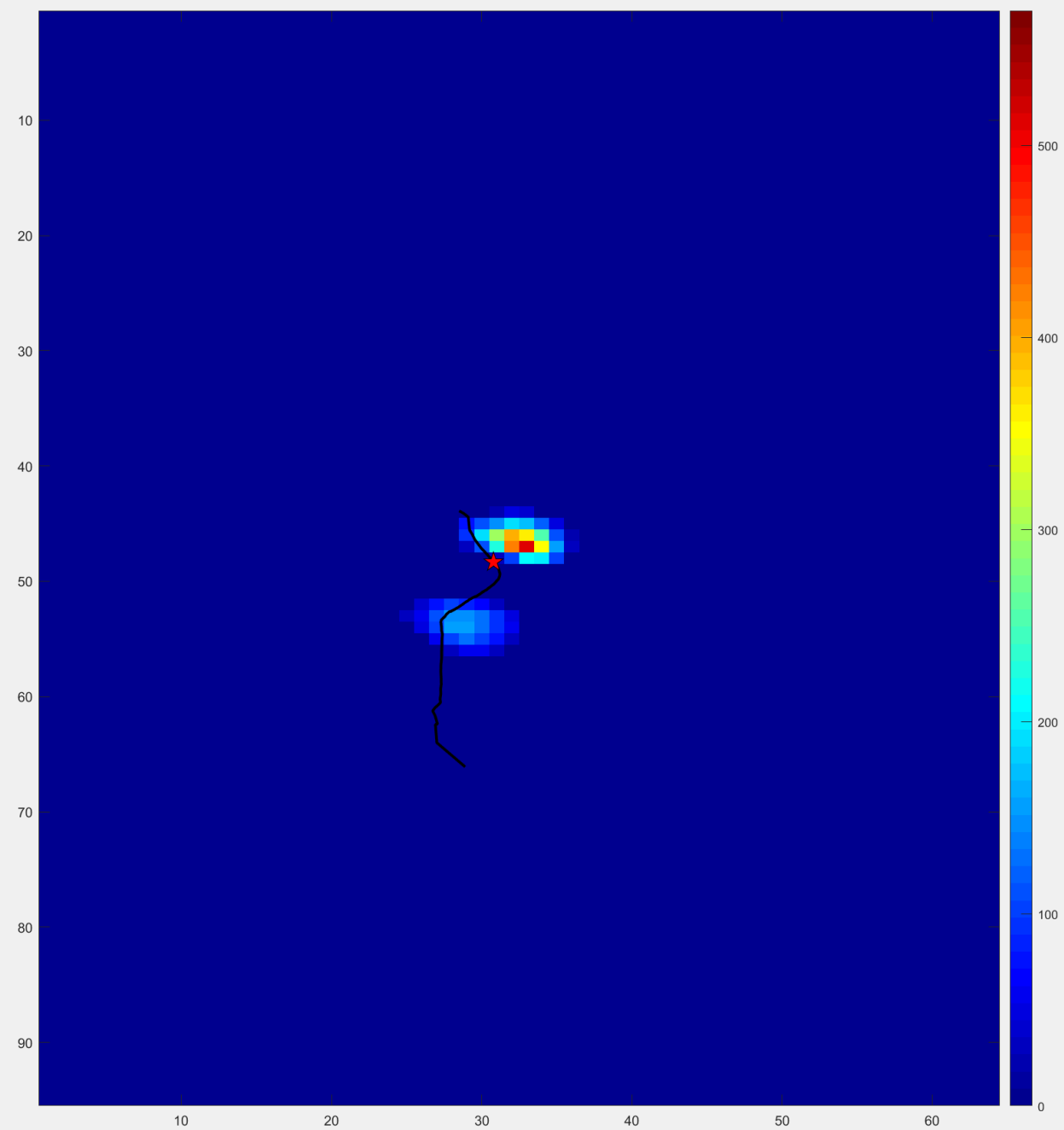

Image 34: The center of pressure across all frames is now recalculated after the foot pressure has been zeroed out.

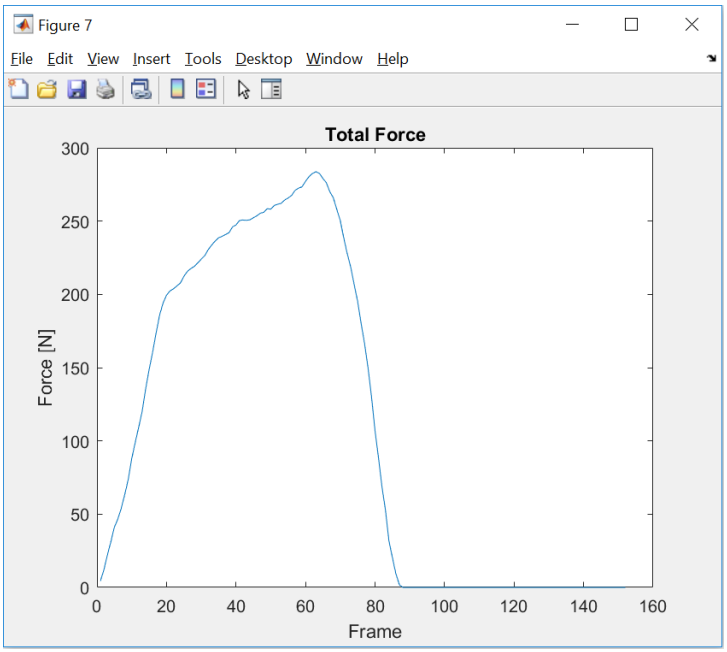

Image 35: New Total Force graph. Notice the immediate drop off where the foot print was zeroed.

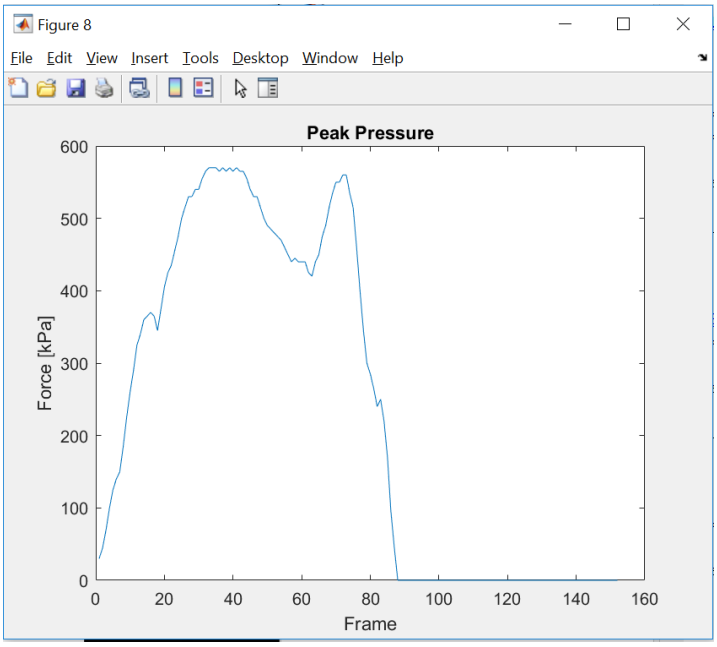

Image 36: New Peak Pressure Graph. Notice the immediate drop off where the foot print was zeroed.

9.

Data Export Tools

To open the Data Export Tools, hit the Show Data Export Tools button on the Image Controller (Image 37).

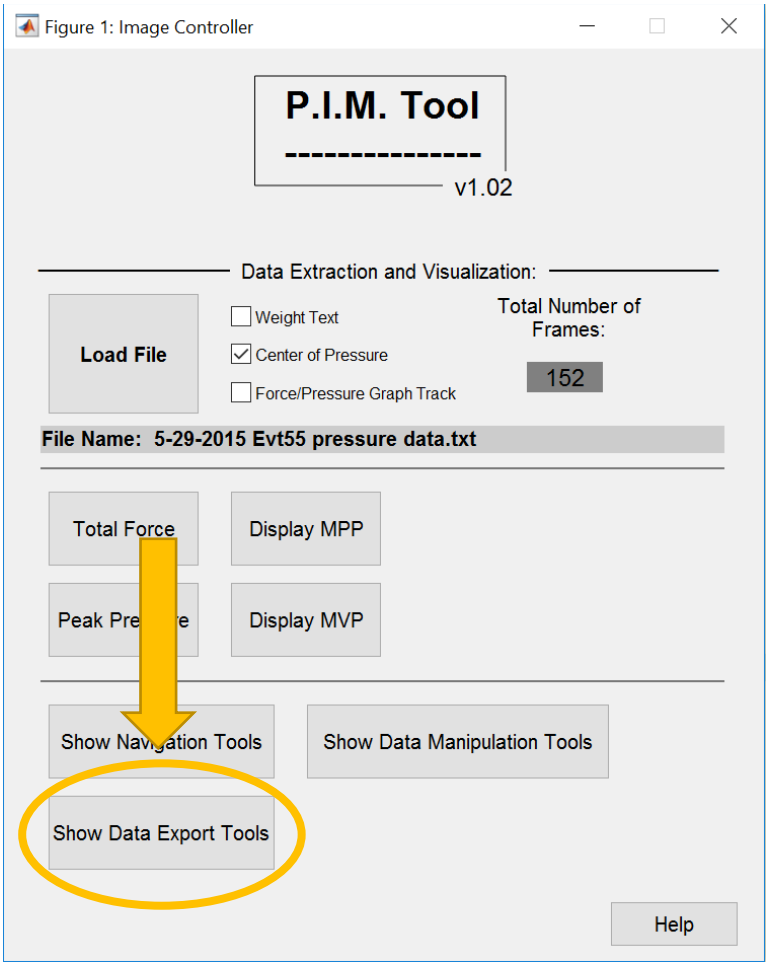

Image 37: Show Data Export Tools button.

A new small window should pop up that looks like Image 38.

Each button and edit box with a short description will be displayed below.

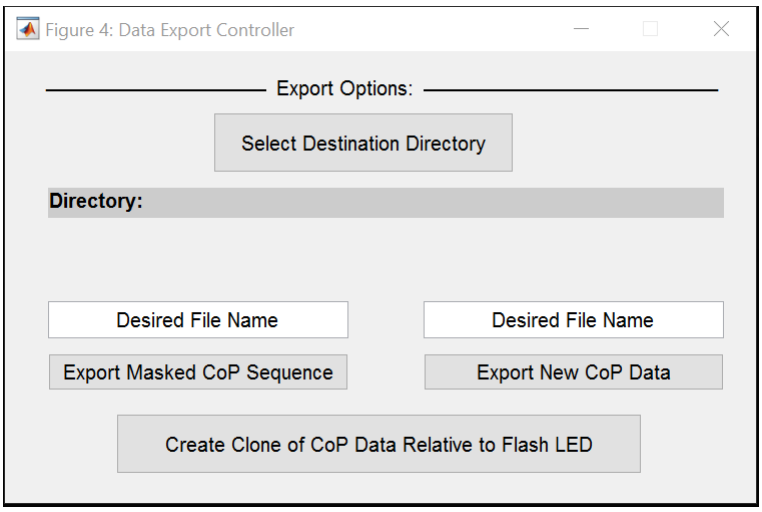

Image 38: The Data Export Controller containing Export Options.

Select Destination Directory – In order for any files to be exported, a destination for the exported files should be selected beforehand. The remaining buttons will not function if a destination directory is not selected beforehand. The selected directory will be displayed below the button. A directory selector box similar to Image 6 is displayed when the button is pressed. Select the Folder/Directory and hit Select Folder.

Export Masked CoP Sequence [& Edit Box] – This button exports the newly calculated coordinates of the center of pressure line of the selected masked area (the pink lines shown in Image 31) after the Calculate Local CoP Data button is selected. The selected masked area is the selected mask in the drop down box on the Data Manipulation Controller DIRECTLY after Calculate Local CoP Data was pressed. The summed forces of the respective area at each frame is also included in the exported data file. The span of forces and coordinates is calculated according to the Frame to Frame numbers input in the Data Manipulation Controller above the Calculate Local CoP Data button.The file itself is exported as a .csv. The name of the exported file is determined by the text in the edit box right above the button. The .csv extension is NOT required to be input in the name.

Export New CoP Data [& Edit Box] – This button exports the newly calculated coordinates of the center of pressure line of the entire force plate (The black line present in Images 8 & 34) across all frames after the Recalculate CoP Data Pressure button is selected. The summed forces of the respective area at each frame is also included in the exported data file. The file itself is exported as a .csv. The name of the exported file is determined by the text in the edit box right above the button. The .csv extension is NOT required to be input in the name.

Create Clone of CoP Data Relative to Flash LED – While the pressure matrix itself displays an origin at the top left of the grid, the user may want the coordinates with respect to the blinking LED which turns on when pressure is detected. This is an equally viable reference, and as such, the Create Clone of COP Data Relative to Flash LED button allows you to create copies of your calculated data adapted to the position of the light (The LED is the new origin). When selecting the Clone button, a file select window similar to Image 6 is displayed. You may select multiple files by either clicking and dragging your cursor to highlight them or holding the CTRL button on your keyboard and selecting the desired files. Then hit the Open button. The PIM tool will create copies of your data files with the world "_relative" appended to the end of each file name to indicate which file has its data relative to the LED.

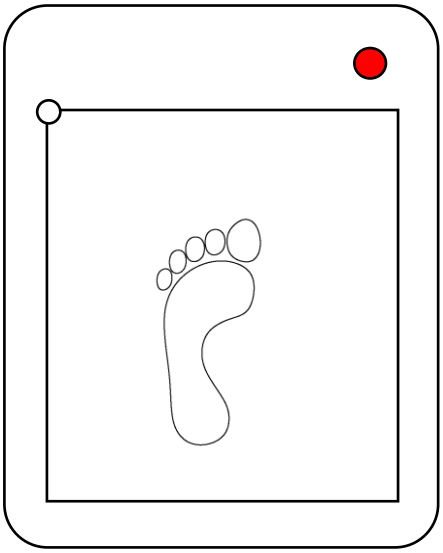

Image 39: Basic graphic of Pressure Pad with Blink LED at top right in red. The normal zero position is at the top left of the grid (the white circle) and is represented in the Visualization Window.

10.

Example Run Through

Now that you've reviewed the entirety of PIM in the past 40 pages, an example walk-through would be useful to see PIM in action, utilizing its many features. As mentioned in Chapter 1, the following example will detail quadrupedal knuckle-walking by chimpanzees. This essentially is the action by which a chimp walks forward on all four limbs, placing their body weight on the knuckles of their forelimbs (Image 40). The hind limb is then brought forward, continuing through the stride (Image 41). Occasionally however, as the hind limb comes forward, the digits of the hind limb may overlap with the digits of the forelimb (Image 42). We'll be exploring an instance like this to fully illustrate the depth to which PIM may be utilized. The following walkthrough is intended to measure the group and individual pressures exerted on each digit of a chimpanzee exhibiting knuckle walking.

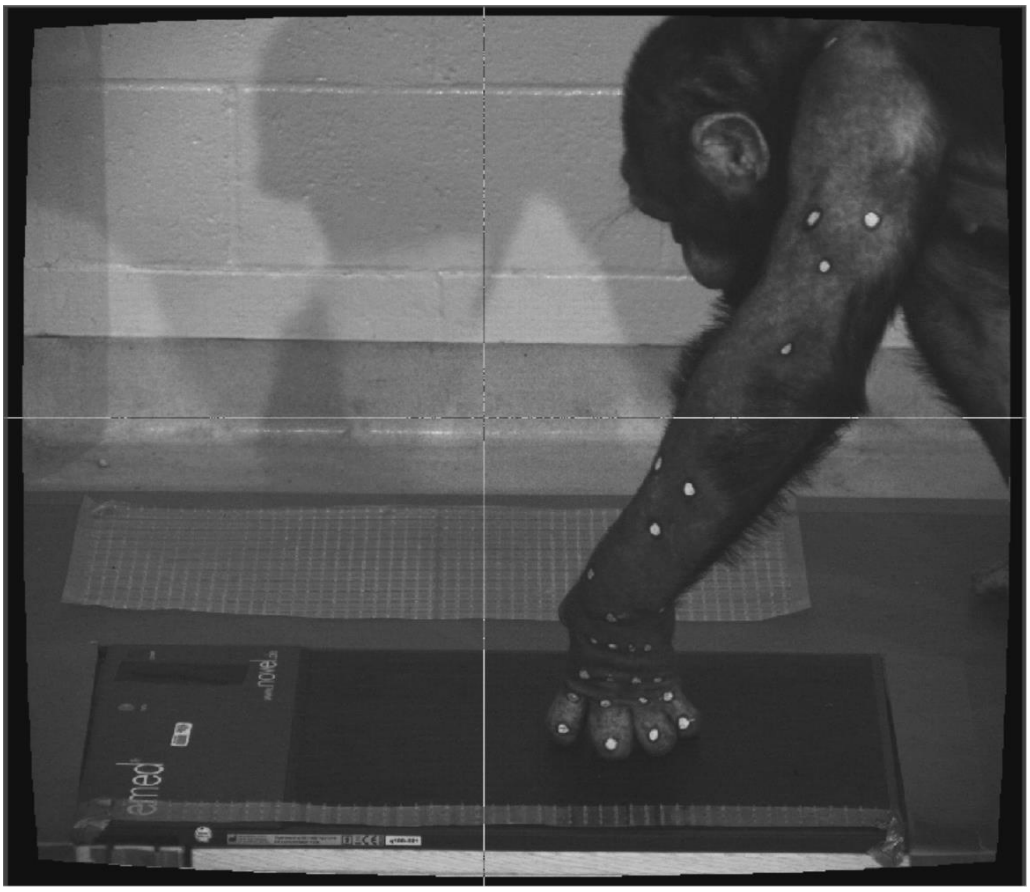

Image 40: Chimp knuckle-walking stride where the knuckles make contact with the pressure pad. Crosshairs are left in frame for distance reference in comparison to Image 41.

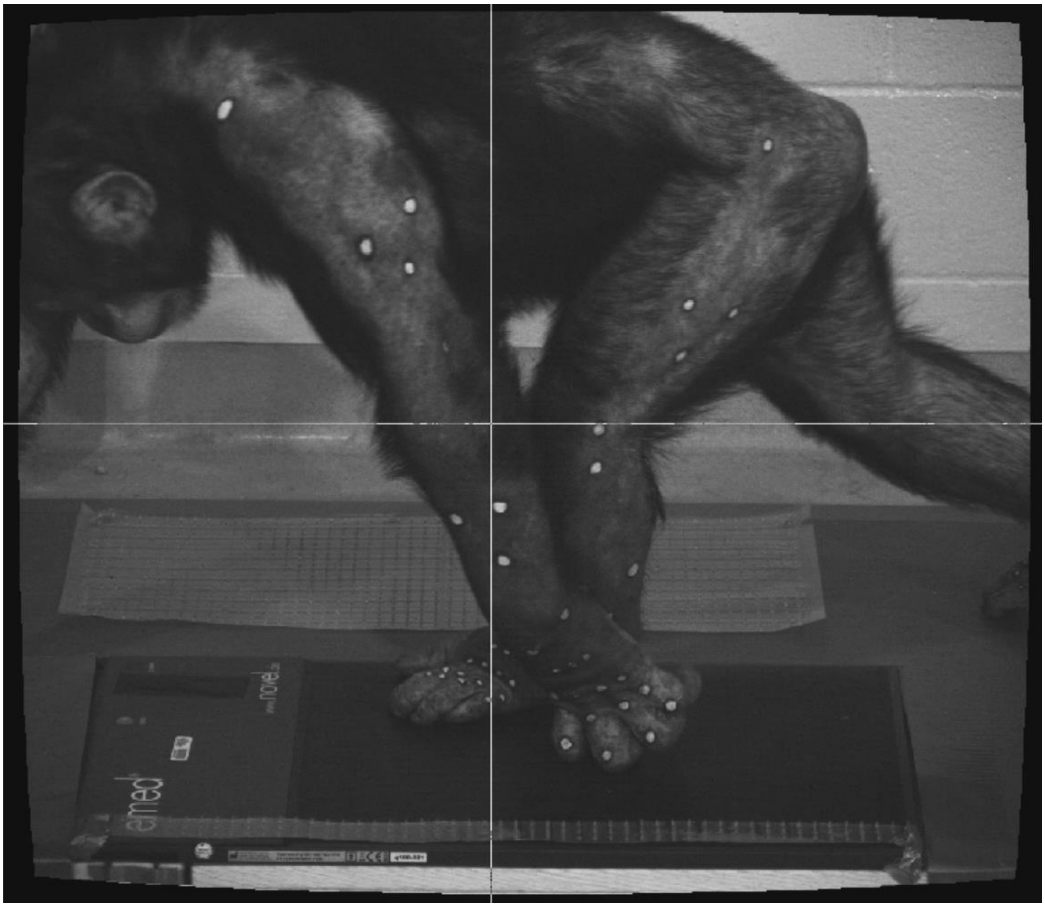

Image 41: Chimp knuckle-walking stride as the left hind limb is brought forward past the knuckles to make contact with the pressure pad. These two contact bases create what you visualize in Images 19 and 20. Crosshairs are left in frame for distance reference in comparison to Image 40.

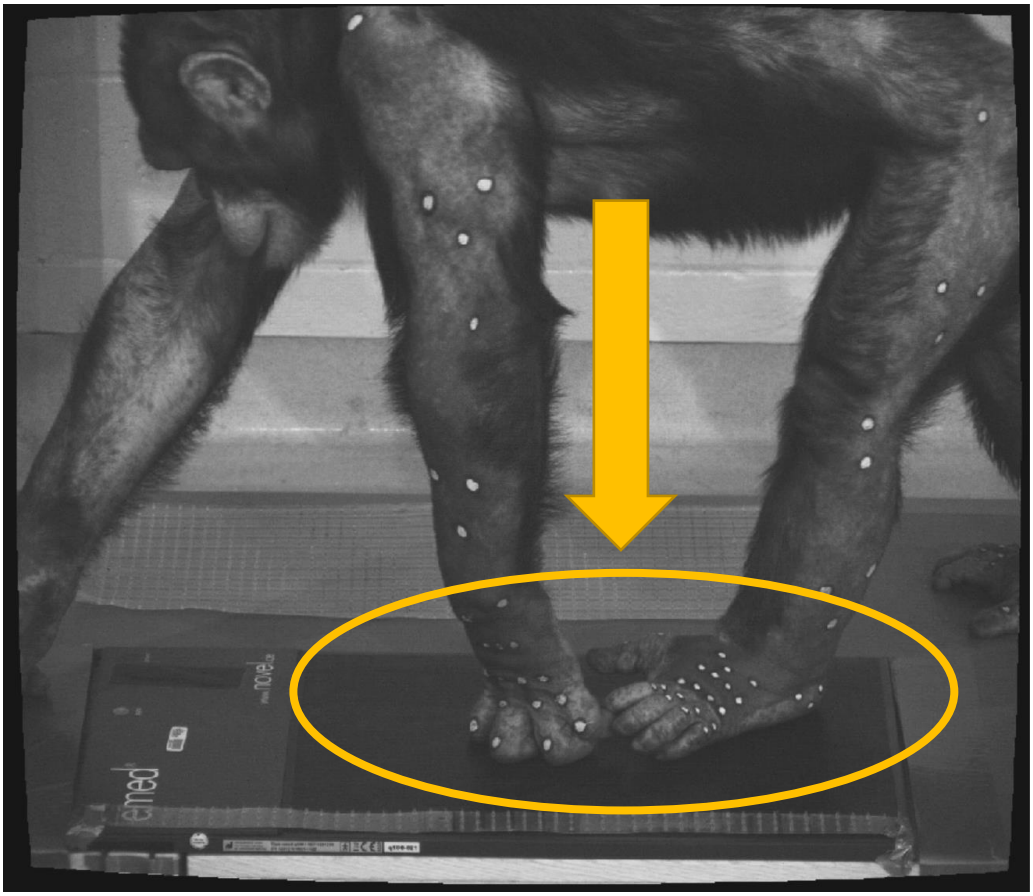

Image 42: Chimp knuckle-walking stride where the digits of the hind limb overlap with the digits of the forelimb.

We'll be following the Steps illustrated below:

Step 1 – Load the raw data file into PIM

Step 2 – Confirm that there is overlap by showing MPP

Step 3 – Navigate through frames and place Point markers to illustrate bounds of overlapped digits and record relevant frames

Step 4 – Mask all digits, zero foot pressure

Step 5 – Recalculate CoP Data and Regraph Force/Pressure

Step 6 – Export new CoP Sequence data and auxiliary graphs

Step 7 – Create Clones of CoP Data relative to Flash LED

STEP 1 – We'll open PIM by typing "PIM" into MATLAB. Then we hit Load File to open the desired file (Images 43 & 44).

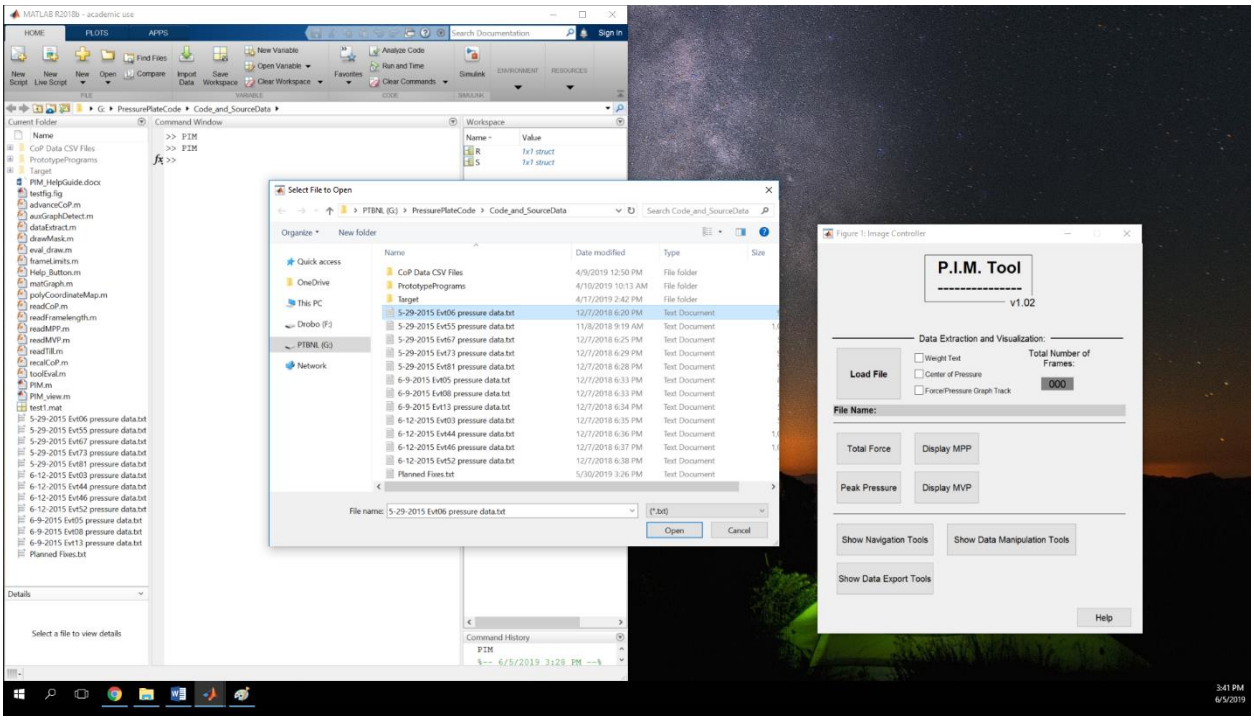

Image 43: The Load File window displayed after PIM was opened and the Load File button was pressed.

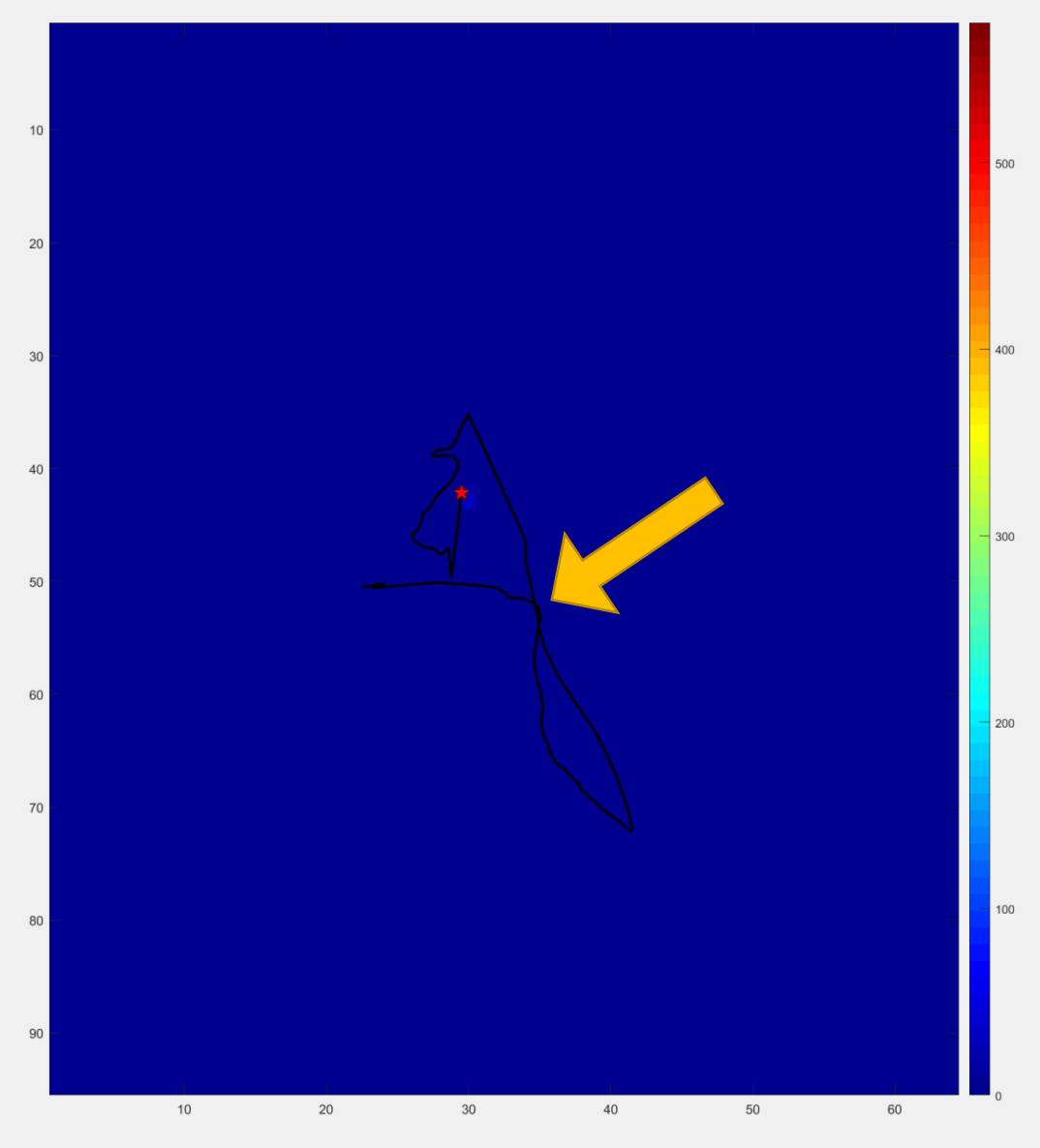

Image 44: The resulting first frame of the raw imported data. Notice how the center of pressure path crosses back over itself.

STEP 2 – We show there is overlap by viewing the MPP visualization. We can see that the pressure cells for the foot and the knuckles overlap (Image 45). Another indicator is that the center of pressure path crosses over itself in later frames (Image 44).

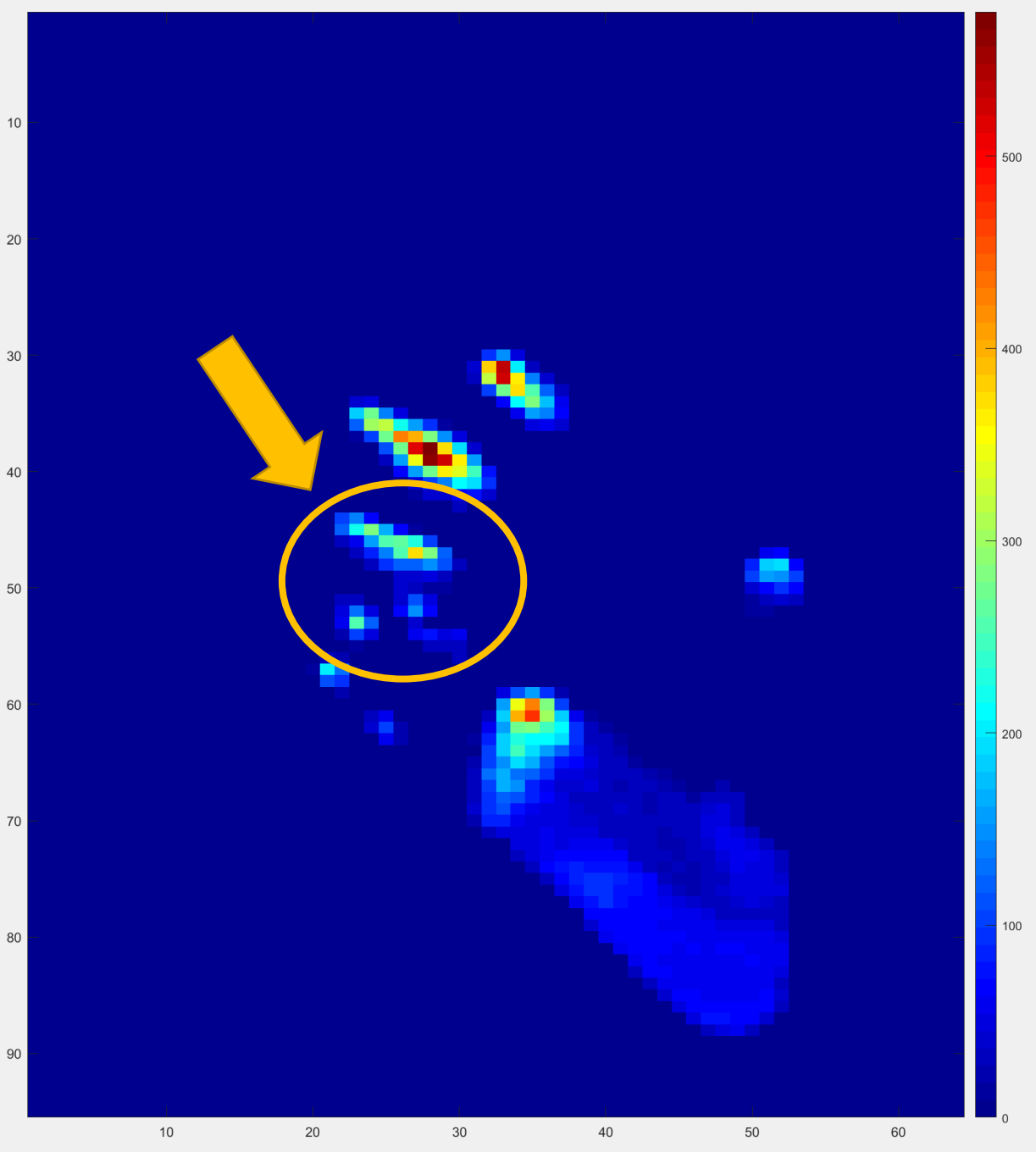

Image 45: The MPP visualization of the raw imported data. The pressure cells displaying the digits of the hind limb and the forelimb appear to overlap.

STEP 3a – We first start by masking the digits we want in the MPP visualization. These will be the digits we are certain do not have overlapping pressure cells (Image 46). We can easily outline these with the Straight Line option.

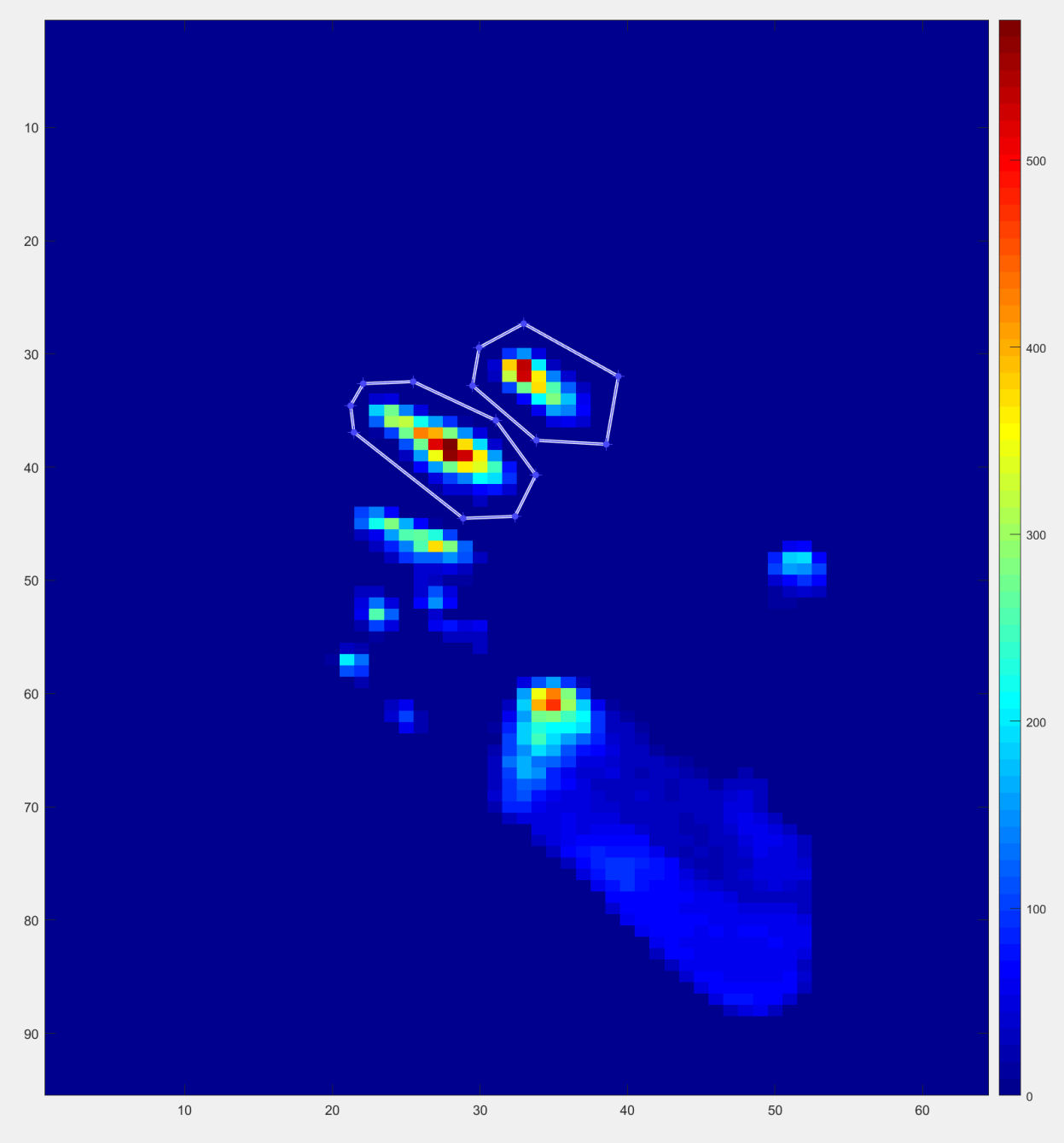

Image 46: The two clear isolated digits (2 & 3) are encircled and masked using the Straight Line draw option.

Step 3b – The Mask button can be hit before proceeding so the already defined masks are not accidentally moved or altered.

Step 3c – Using the Navigation Tool, we can deduct from parsing through the frames moving forward that the 5th digit appears at frame 2 and disappears at frame 33. The 4th digit also

appears at frame 2 and disappears at frame 80. We will use this information to not only encircle the digits in point markers for easier masking, but also for local CoP calculations.

Image 47 is reached by navigating to frame 2 and placing a point marker on each side of the visible pressure cells activated where digit 5 is indicated to make contact. Proceeding forward one frame, the point markers are then moved using the Fix option on the Draw Tools Controller, expanding outward to better encircle the entirety of the activated pressure area. This process continues to frame 32. Extra point markers are added for better clarification of the surrounding boundaries. The same process is repeated for Image 48 on digit 4.

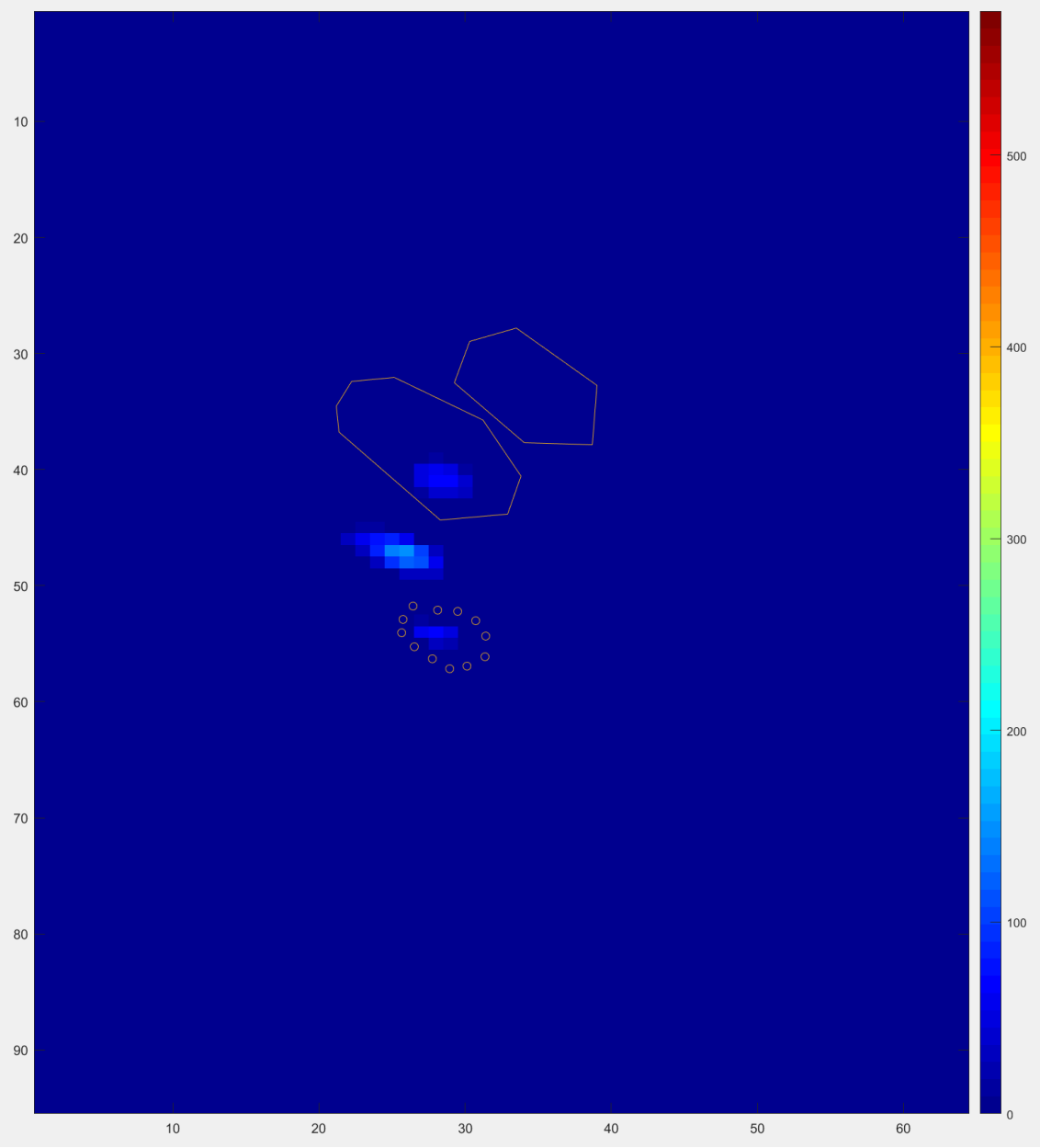

Image 47: The 5th digit is encircled in point markers for boundary indication in masking.

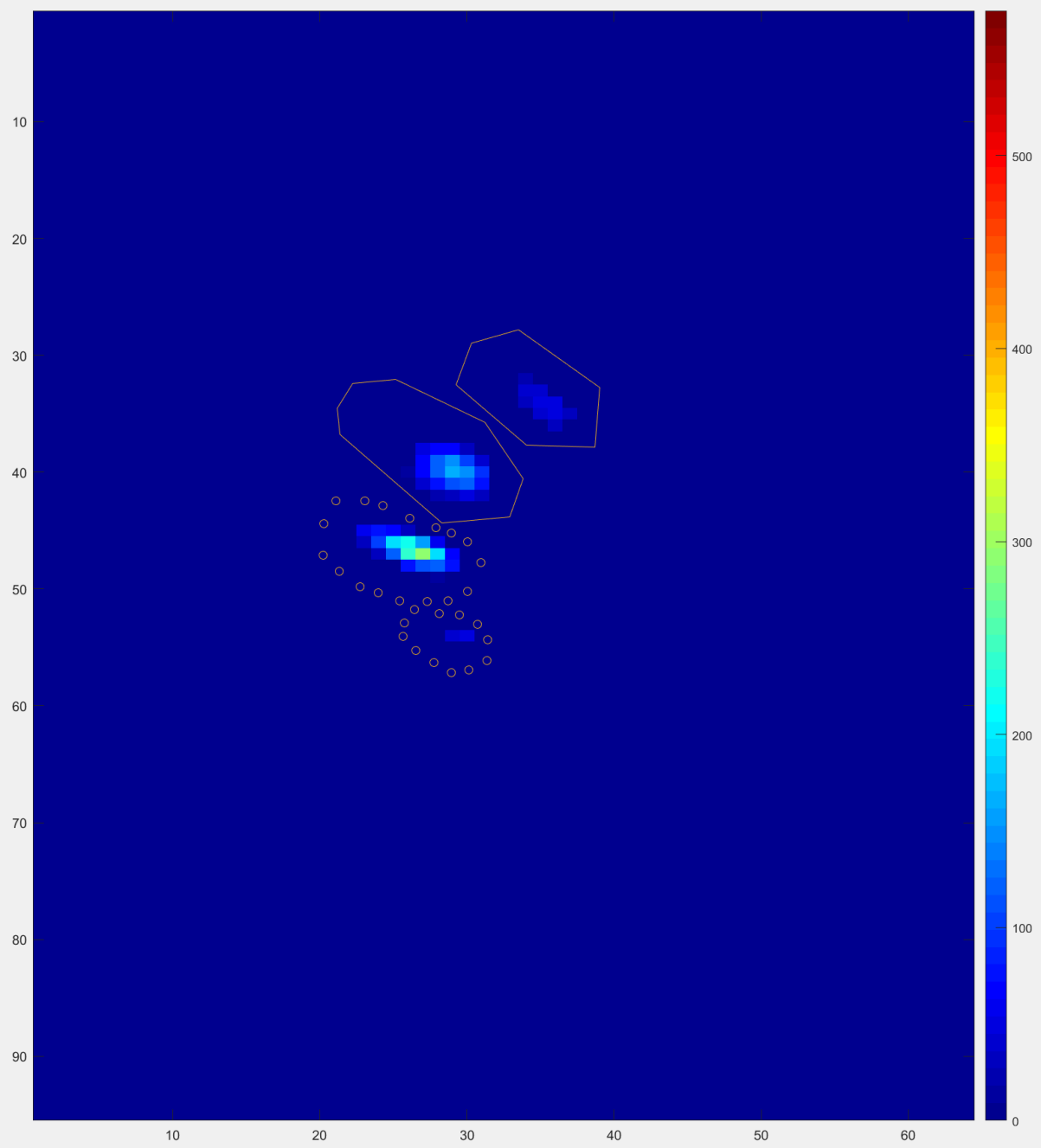

Image 48: A continuation of Image 47. The 4th digit is now encircled in point markers. Notice the masks are an orange color, selected using Select Mask Color for consistency.

Step 3d – Now that both digits are encircled in point markers, we can draw masks around each of them using the indicated boundaries. For greater control, the free hand tool option is used. Following the point markers, the two masks in Image 49 are drawn.

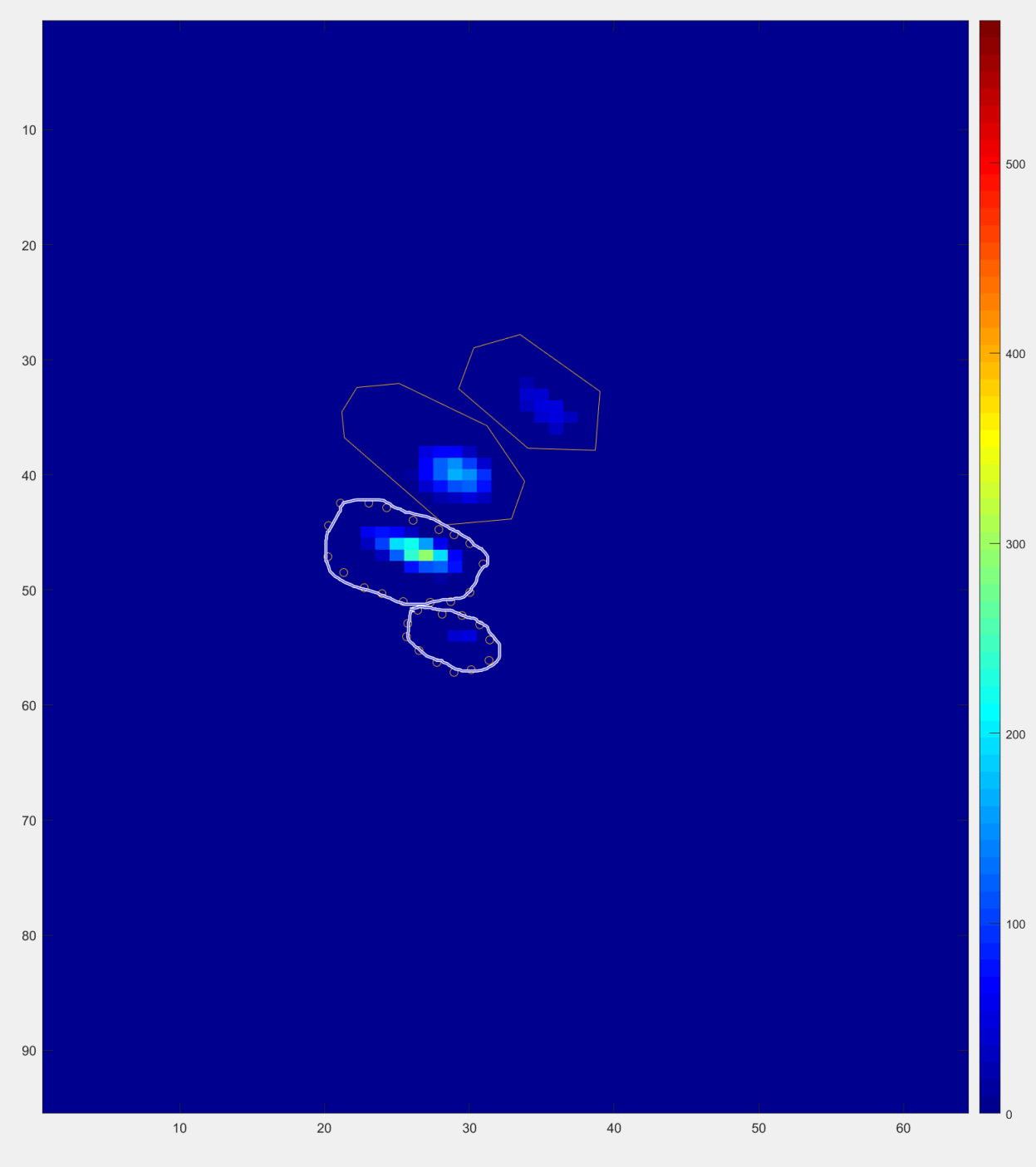

Image 49: Free hand masks are drawn around digits 4 and 5.

Step 4a – Now that all the desired masks are drawn, the mask button may be pressed to cement the encircled cells in the image. For ease in visually identifying the lines, the Clear Point Markers button is pressed. Display MPP is pressed and the Highlight Previously Masked Area is toggled off and on to refresh the displayed masks. We now have Image 50.

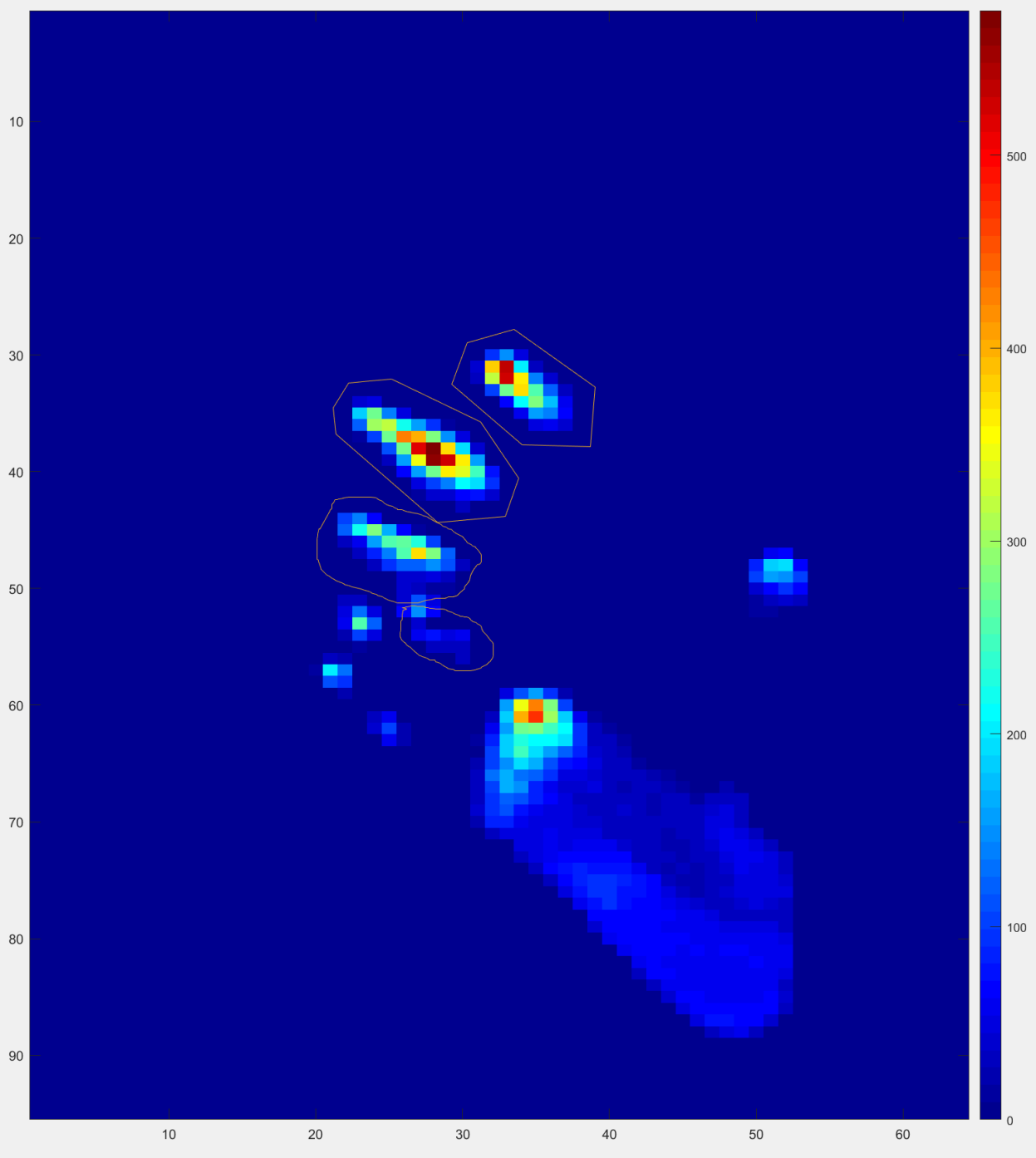

Image 50: The four digits are now masked as indicated above. These shapes are Polygons 1 & 2 and Free_Hands 1 & 2.

Step 4b – Now, we can encircle the foot itself and zero it out. Using the MPP for ease of identification, the Rectangle tool is used to encircle digits 1 and the sole/heel of the hind limb. The Ellipse tool is used to encircle digits 3, 4, and 5, as the ellipse tool is curved

and easier to encircle the digits in such a crowded space. Digit 2 was identified by moving forward to frame 114 where it starts to appear. A rectangle was used to encompass the general surrounding area (instead of using Point Markers) because there are no forelimb digits present at the time the hind limb digit 2 is present, so care does not need to be taken to separate the two. A nondiscriminatory bounding box is drawn around the digit and masked to be zeroed between frames 114 and the final frame, 165.

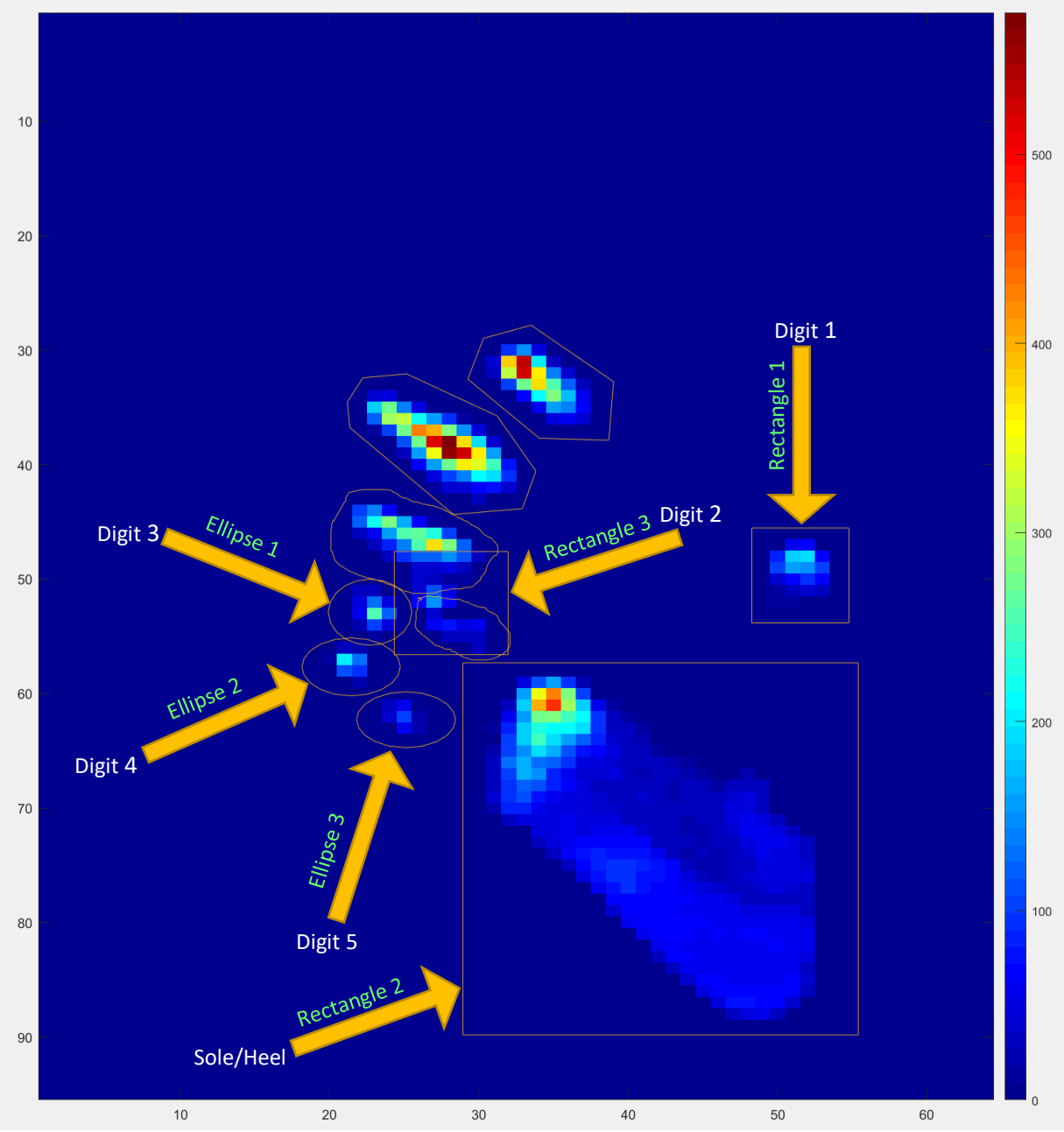

Figure 51: All 5 digits of the hind limb are now masked.

Step 4c – Now that all the masks have been drawn, the corresponding masks for the hind limb may be zeroed accordingly. Ellipses 1, 2, and 3 are selected in the dropdown list on the Data Manipulation Controller and Change Selected to Zero is hit. The same process is repeated for Rectangles 1 and 2. All the previous zeroing actions were performed from frame 1 to frame 165 (the end frame). For Rectangle 3 (Digit 2), we need to specify that only from frame 114 onward should be zeroed. The indicated frames are changed (Image 52) and the Change Selected to Zero button is hit.

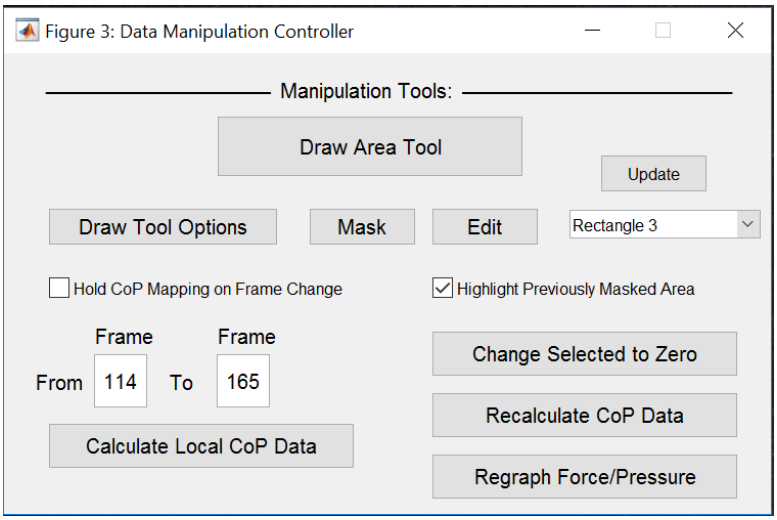

Figure 52: The frames are changed according to when the hind limb 2nd digit is present.

Step 4d – Now that everything's been zeroed, it is useful to double check that the previous processes were carried out correctly. To confirm the zeroing went well, we use the Data Navigation Controller to scan across the newly altered data for any visual discrepancies that indicate an error. << is hit to start at frame 1. Forward => is then clicked to proceed gradually to the end frame. As the frame increments, the zeroed areas should no longer show up as activated cells. (The MPP will still remain the same however for reference purposes.)

Step 4e – For visual clean up, the ellipses and rectangles masking the hind limb are deleted using the Edit button. Each shape mentioned is right clicked and deleted, resulting in an image similar to Image 50. The Update button is then used to update the drop down box so only the correct shapes are usable (Image 53).

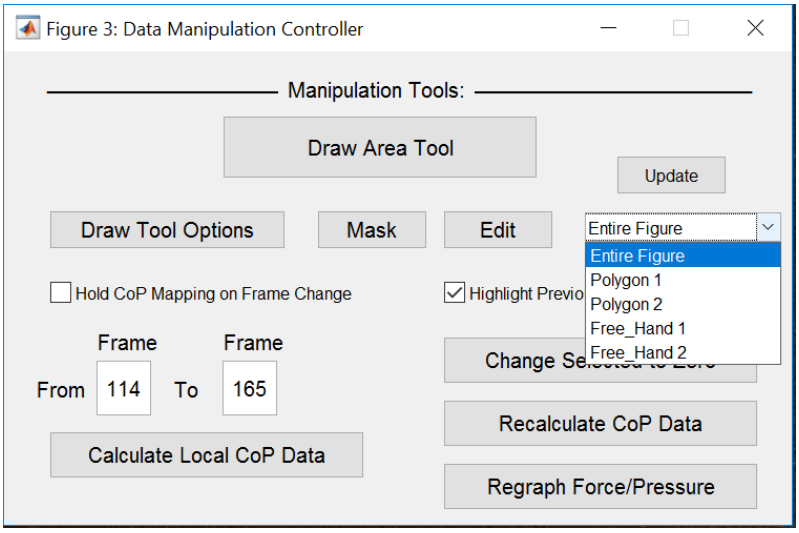

Image 53: The updated dropdown list after the Rectangles and Ellipses have been deleted.

Step 5a – The Recalculate CoP Data button may now be pressed, recalculating the center of pressure path across the entire data set. To double check that this was carried out correctly, make sure the Center of Pressure checkbox is checked so the pathway itself is visible on the Visualization Window. The same reaffirmation process detailed in step 4d is used. The center of pressure star should be easy to follow as the frames increment, tracing out the newly calculated center of pressure pathway. The Regraph Force/Pressure button may also be pressed and visualized in a similar way. The Total Force and Peak Pressure graphs should be opened using their corresponding buttons on the Image Controller. The Force/Pressure Graph Track checkbox on the image controller is checked so that when the frame increments, a star follows along the newly calculated graph. The newly graphed drop off should occur directly as the forelimb digits disappear (Image 54).

Step 5b – With the newly calculated center of pressure pathway, we can now calculate the center of pressure pathway of each digit individually over time. Select each mask from the drop down list and hit the Calculate Local CoP Data button. Make sure the Frame to Frame numbers are reset from 1 to 165 (or the desired range). With the hind limb zeroed out however, the entire range of data can be used in this instance. We'll get a result like Image 55 when displayed on top of the MPP. The MATLAB terminal command window should display the corresponding values.

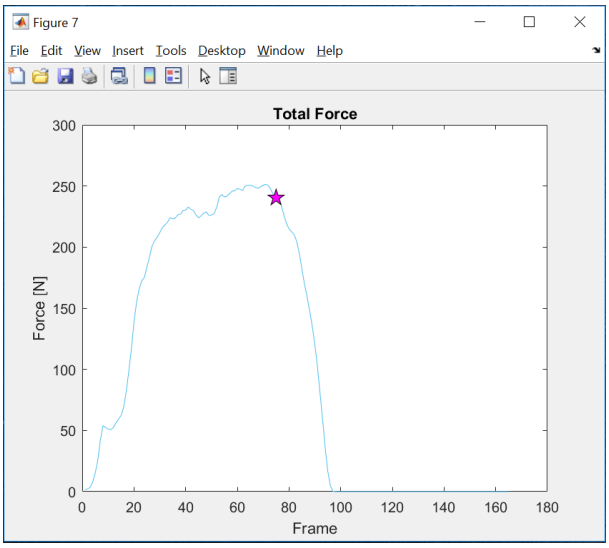

Image 54: The newly calculated Total Force graph.

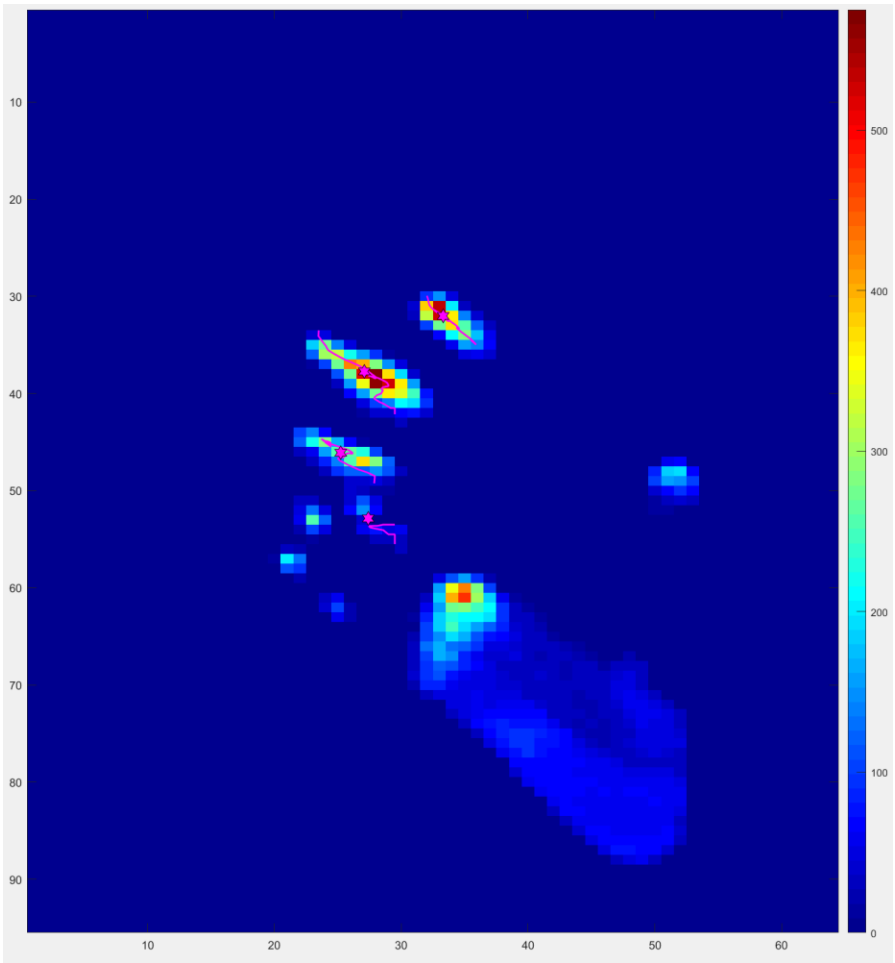

Image 55: The individual center of pressure pathways per digit.

Step 6 – We can now proceed to export our data. Clicking the Show Data Export Tools, the Data Export Controller is displayed. The first step always before exporting is selecting the directory the output files will be placed in. In this instance, a folder called ExampleDirectory is being used (Image 56). For each desired digit, select the corresponding mask in the drop down box in the Data Manipulation Controller and write a desired file name in the box above the Export Masked CoP Sequence button. Click the button below when done. This is done for each of the 4 digits. The Export New CoP Data button on the right is clicked after a giving it a name above as well. This will export the center of pressure data across the entire data set including all of the digits.

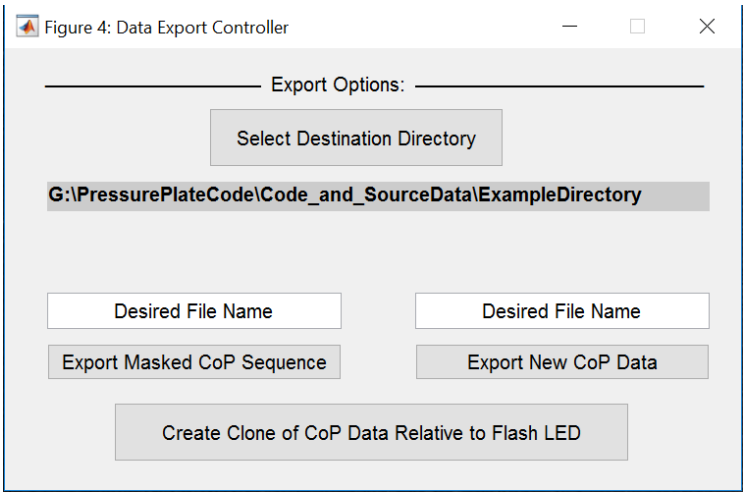

Image 56: The Data Export Controller after a directory has been selected.

Step 7 – The last and final step is simple. If the data coordinates relative to the LED is desired instead, simply click the Create Clone of CoP Data Relative to Flash LED button to open the file selector. Navigate to the directory holding your newly exported data files and select the file you want to convert. If more than one file is desired, simply hold either CTRL and select the files you want, or pick the top file, hold SHIFT, then select the bottom file to select all files (Image 57). Hit open and the conversion should happen immediately. If you navigate to your target directory, you'll see new files with the '_relative' suffix appended among your original files. And that's it!

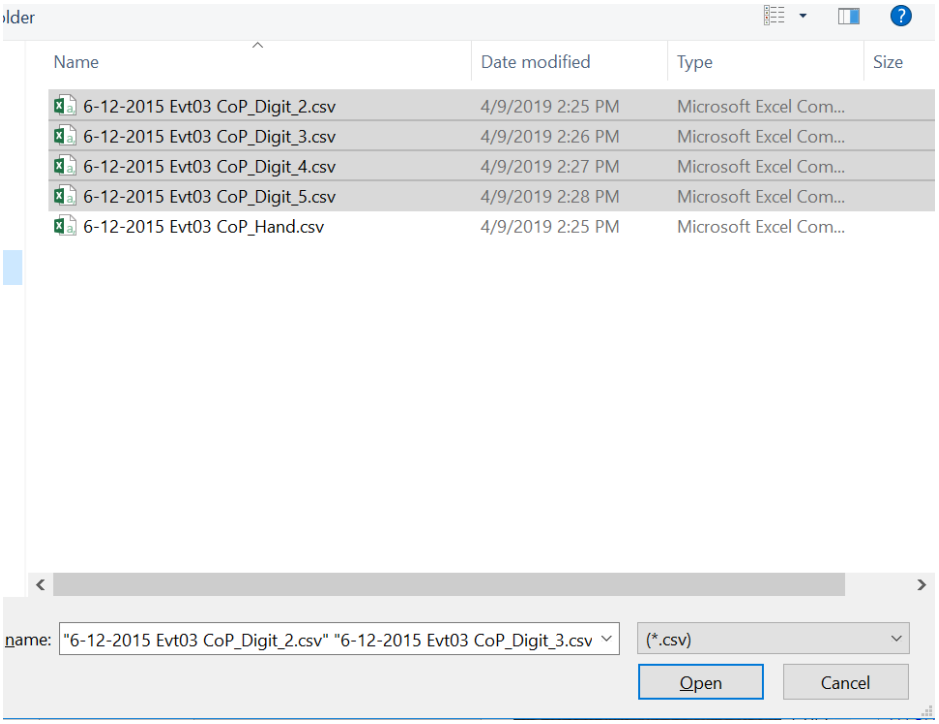

Image 57: Selecting multiple files to convert to relative coordinates to the LED.

NOTE: As of now, loading a new file into PIM will not clear the previous document thoroughly. For now, if you want to continue using PIM to analyze another pressure file, save all the graphs, .csv files, and images you need. Then simply run PIM again. It will by default clear the variable workspace and force close all other figures. A reset button should be implemented in a future release.

11.

Final Thoughts

PIM is a small but capable tool of capturing and visualizing pressure pad data for a multitude of follow up procedures. Any and all criticisms are appreciated, as they help the development of not only PIM, but any future programs that may be released. Thank you for using PIM! Included below is a list of features which will be implemented in future updates. If you have any further ideas, please feel free to contact either myself or Dr. Thompson. Happy analyzing!

Future releases:

Reset Button

Load Session from Previous Session file button

MPP and MVP Zeroing Capabilities

Unit selection [N or kPa] for Total Force and Peak Pressure Graphs

Log of Past Actions