

Exploring JMP®'s Image Visualization Tools in Medical Diagnostic Applications

Melvin Alexander, Social Security Administration

ABSTRACT

Among JMP®'s powerful, graphical functionalities is the ability to open, display, and analyze data from images. This capability converts pixel values from images into data tables and matrices. Once data are in data tables, additional analyses and data visualizations may be performed.

This presentation will demonstrate these capabilities using examples from medical computer tomographic (CT) images that are viewed for signs to diagnose patients with specific injuries and medical conditions. Results of the image analyses help radiologists and clinicians decide the medical treatment options to give to patients (e.g., surgery, non-operative management, targeted radiation-beam therapies).

Combining the statistical, graphical and data analytic functionality of JMP® extends information visualization beyond what can be seen with standard image interpretation. Ways to replicate these visualizations in SAS® will also be discussed.

INTRODUCTION

This presentation will review ways of using JMP® to convert pixel values from images (i.e., discrete numerical representations of colors in GIF, PNG, JPG formats) into data tables and matrices. Once data are in data tables, additional analyses and data visualizations may be performed. These capabilities will be demonstrated using examples from medical computer tomographic (CT) images. CT images are special types of X-rays that are three dimensional cross-sections of internal body organs. Radiologists and medical clinicians look for certain signs in these images to diagnose patients with specific injuries and/or medical conditions. Results of the image analyses help radiologists and clinicians decide the most appropriate medical treatments to give to patients (e.g., surgery, non-operative management, targeted radiation-beam therapies for cancer).

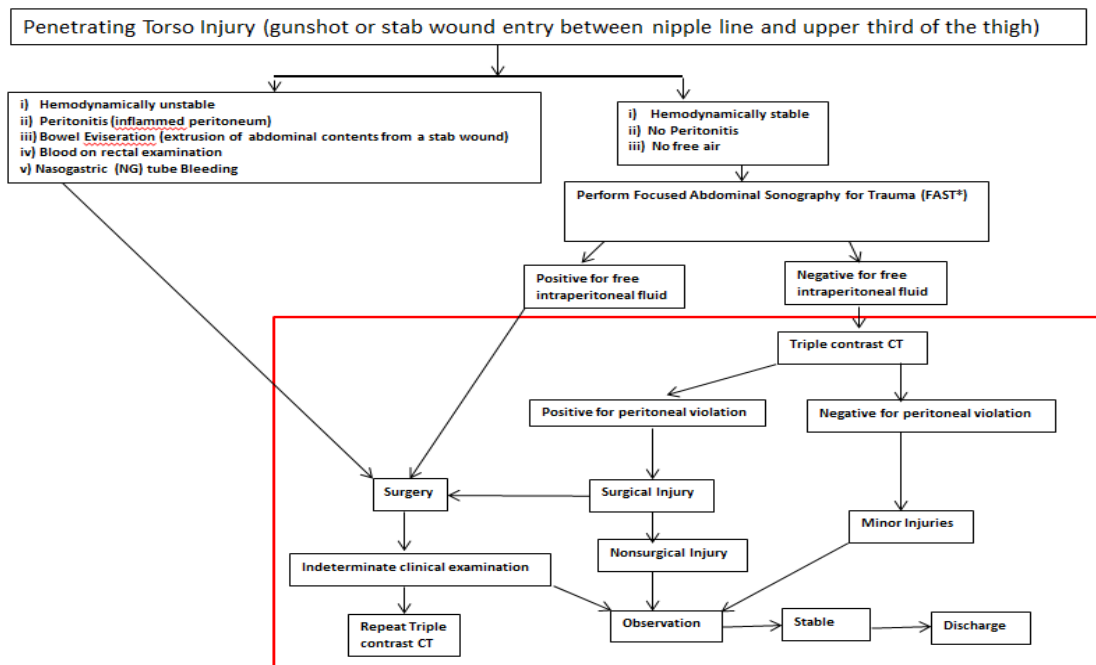
Combining the statistical, graphical and data analytic functionality of JMP® extends information visualization beyond what can be seen with standard image interpretation. Ways to replicate these visualizations in SAS® also will be discussed.

EXAMPLE

The first example was taken from a study, Saksobhavit et al. [13], intended to assess the diagnostic accuracy of CT imaging in detecting penetrating gastrointestinal (GI) injuries (i.e., gunshot or stab wounds into the abdomen).

Figure 1 shows the protocol flow of patient movement after admission into a trauma center for penetrating, abdominal gunshot or stab wounds. No Peritonitis means that patients had no inflamed [peritoneum](#) (i.e., membrane lining the abdominal wall and internal tissues) nor the presence of free air or gas in the abdominal (peritoneal) cavity. The right side of the FAST path (inside the red rectangle) determines the patient treatment course options (surgery, observation, discharge) based on CT findings.

Figure 1: Triple-Contrast Imaging Algorithm for Stable Patients with Penetrating Trauma

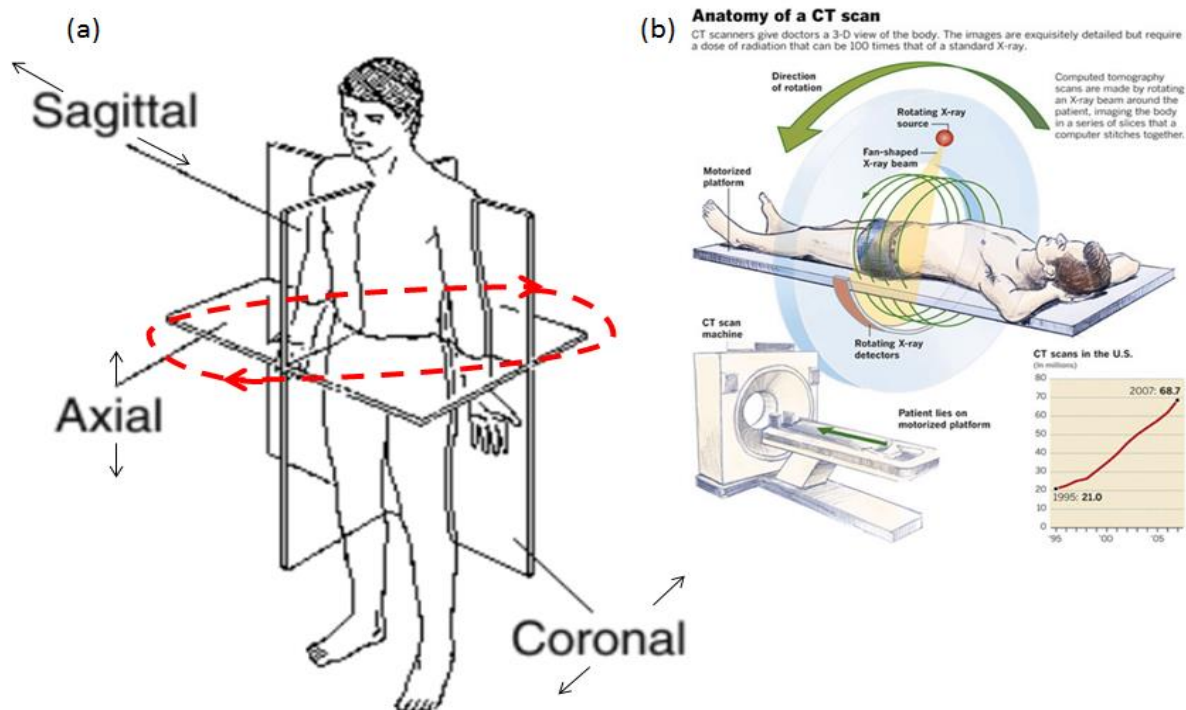


* Focused Assessment with Sonography for Trauma (FAST): Rapid Sonographic, Ultrasound, MDCT Examination used by radiologists, surgeons, emergency physicians and certain paramedics to screen for blood around the heart or abdominal organs after trauma.

Figure 2(a) showed the three-dimensional anatomical planes (axial, coronal, and sagittal) where cross-sectional body slices are recorded during CT imaging.

Figure 2: Anatomical Planes that capture image frames of CT scans

Sources: <http://webdocs.cs.ualberta.ca/~btap/Images/planes-body.gif>,
<http://www.cogneuro-lab.org/UserFiles/Image/CT.jpg>



The Axial (or transversal) plane records from top-down (head-to-toe). The Coronal plane captures the body from front-to-back. The Sagittal plane scans the body from the left-to-right shoulder. Each image frame depicts the body organ's structure, location, direction, and movement.

Typically, a patient lies on a table that slides through a tunnel (Figure 2b). A rotating ring, called a gantry, sends x-ray beams around the body in a spiral path (represented by the dashed circular ellipse in Figure 2a). Different body parts absorb varying degrees of x-rays as the table moves through the scanner. Bones appear white on the x-ray. Soft tissue organs like the heart, bladder, or liver shows up in shades of gray. Air (or gas) appears black. The cross-sectional images from the CT scanner are: (1) reformatted, (2) viewed on a computer monitor, (3) printed onto film, (4) transferred to a CD or DVD, and (5) stored into a Picture Archival Communication System (PACS).

Table 1, from Alexander [1], lists 16 signs used in an inter-rater reliability study of independent radiologists for detecting penetrating GI torso injuries.

Table 1: Signs Indicating Penetrating GI Torso Injuries

Source: Alexander (2014), <https://community.jmp.com/docs/DOC-6674>

JMP Column	Sign	Peritoneum – Membrane (thin tissues) that lines the abdomen and inner abdominal organs
Q1	Peritoneal violation	Indirect sign of injury to the peritoneum
Q2	Retroperitoneal violation	Indirect sign of injury to retro-peritoneal colon
Q3a	Free gas at wound track	Indirect sign of free intraperitoneal/retroperitoneal gas adjacent to the GI injury site
Q3b	Free gas away from wound track	Indirect sign of free intraperitoneal/retroperitoneal gas remote to the GI injury site
Q4	Intramural gas	Direct sign of intramural air
Q5	Leakage of luminal content	Direct sign bleeding into GI lumen (inside space of intestinal tubular structure)
Q6	Leakage of oral/rectal contrast	Direct Sign of leakage of enteric contrast material
Q7	Discontinuity of bowel wall	Direct sign of GI
Q8	Bowel wall thickening	Direct sign of peritoneal thickening or enhancement
Q9	Free fluid	Indirect sign of free intraperitoneal fluid
Q10	Mesenteric hematoma	Indirect sign of blood leakage into intestinal organs
Q11	Active mesenteric bleeding	Indirect sign of extensive hemorrhaging into intestinal organs
Q12	Signs of peritonitis	Indirect sign of peritoneum inflammation
Q13	Signs of solid organ injury	Indirect sign of injuries to other abdominal organs
Q14	Intraluminal bleeding	Direct sign of bleeding into GI lumen
Q15	Wound track extending up to bowel	Direct sign of visible penetrating wound track hemorrhage, air, and/or ballistic fragments that extended up to the GI wall

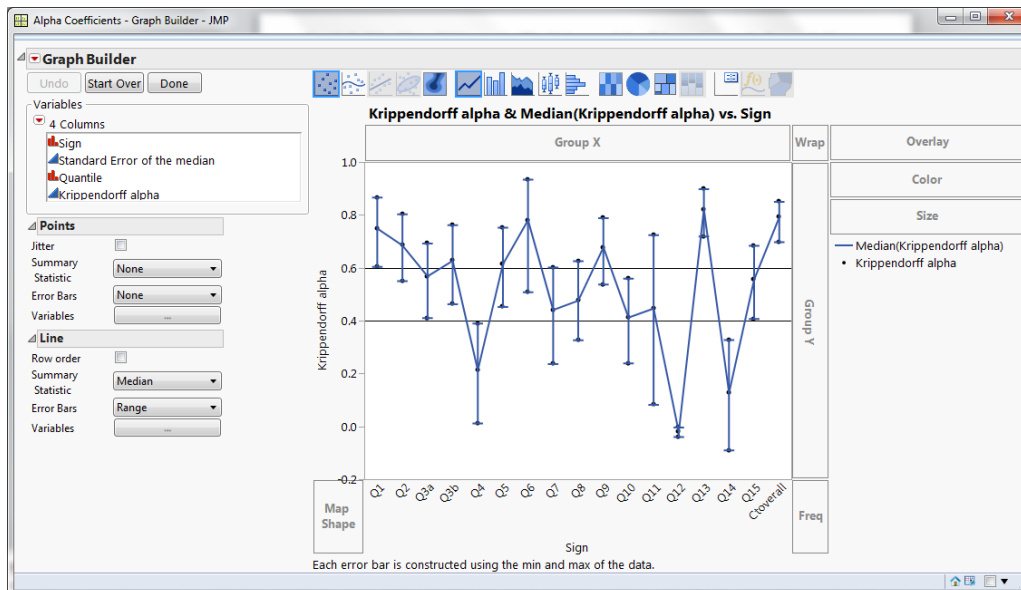
Primary or direct CT signs that relate to GI injury include: Q7-GI wall discontinuity; Q8-subjective GI wall thickening; Q4-intramural air; Q14-bleeding into GI lumen; Q6-leakage of enteric contrast material; Q5-visible leakage of any GI content if enteric contrast was not present at the injury site; and Q15-visible penetrating wound track outlined by hemorrhage, air, and/or ballistic fragments that extend up to the GI wall.

Indirect or secondary CT signs include any evidence of: Q1-peritoneal violation; Q2-retroperitoneal violation; Q3a-free intraperitoneal/retroperitoneal gas adjacent to the GI injury site; Q3b-free intraperitoneal/retroperitoneal gas remote to the GI injury site; Q12-peritoneal thickening or enhancement; Q13-co-existing penetrating injuries to intraperitoneal solid organs; Q9-free intraperitoneal fluid; Q10-mesenteric hematoma; and Q11-active mesenteric hemorrhage.

All CT signs and an overall CT diagnosis of GI injury were rated using a five-point confidence scale (1-definitely absent, 2-possibly present but unlikely, 3-equivocal, 4-likely present, 5-definitely present).

Figure 3 shows results of the inter-rater reliability measures (Krippendorff's alpha or Kalpha) that differentiated between three independent raters (radiologists) agreements and disagreements viewing the same images for specific signs indicating GI torso injuries using the 5-point confidence scale.

Figure 3: Graph Builder Plot of Inter-rater Reliability Measures of Krippendorff's Alpha (Kalpha) and Confidence Intervals for each Sign by 3 Independent Radiologists



Kalpha values above 0.8 (Q13 –solid organ injuries and Ctoverall) indicated good reliability in detection between raters. Signs Q4 (Intramural gas), Q12 (peritonitis), and Q14 (intraluminal bleeding) had confidence intervals below 0.4, indicating poor reliability and the need for more medical training for radiologists so that they can improve their ability to detect these factors as indicators of GI tract injuries.

Figure 4a of Saksobhavivat et al. [13] shows an Axial (top-down) view of a gunshot wound to the left pelvis with rectal contrast material extravasation.

Figure 4a: Axial Image from Saksobhavivat et al. (2016) of Penetrating GI Tract Injury (Reprinted with permission from the European Society of Radiology)

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16 March 2016
**Diagnostic accuracy of
triple-contrast
multi-detector
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gastrointestinal injury:
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Extravasation is where contrast media has leaked into surrounding tissues. Reformatted CT images demonstrate a wound tract (Q15, arrowheads) outlined by hematoma, bullet and bone fragments. There is both a descending colon (Q13, curved arrow) and jejunal wall (Q8, white arrows) thickening. Rectal contrast material (Q6, red arrows) extravasation can be seen throughout the peritoneum.

Hematoma is swelling of clotted blood within tissues. The jejunal wall makes up 20 percent of the small intestines and is used to evaluate the small bowel during follow-through evaluation (a.k.a. SBFT).

The arrows and arrow-heads point to certain signs that radiologists look at that help diagnose patients and determine effective medical treatments.

Figure 4a1 shows the same image read into JMP using the JSL code below:

```
// This script reads in an image and stores each pixel as a row in a datatable.
// The pixels values are represented in three ways:
//   red, green and blue (r, g, b)
//   hue, lightness and saturation (h, l, s)
//   intensity (i)
//
//
img = NewImage("L:\Nitima\Manuscript draft\GSW 4a.GIF");
/*****
Source: John Ponte (2014), "ImageToDataTable JSL",
https://community.jmp.com/docs/DOC-6100
*****/
NamesDefaultToHere(1);
// Read the MDCT image from Saksobhavivat et al.(2016), European Radiology into JMP

xs = 0.5; /* Scales image to half its original size */
img << scale(xs);
newWindow("Axial CT Image of GSW to left pelvis from European Radiology (2016), \n
used with permission from the European Radiological Society and Springer", img);
// Get the pixel values as 3 distinct matrices (red, green and blue)
// RGB colors are in normalized color space (0.0-1.0)
{r, g, b} = img << getPixels("rgb");
```

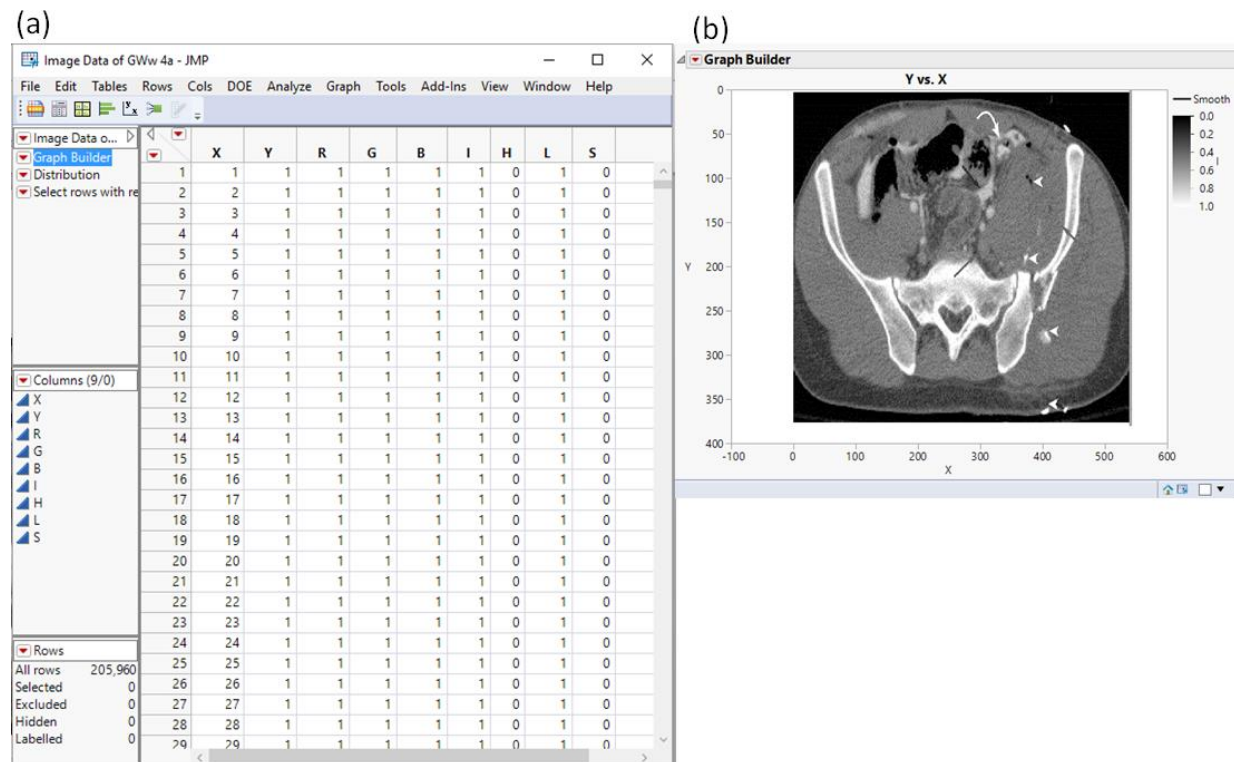
The JMP Scripting Language (JSL) code, adapted from Ponte [8], reads the image of Figure 4a into the new window Figure 4a1. The pixel values from the image of Figure 4a convert into matrices of red, green, blue (RGB) colors.

Figure 4a1: Image of Figure 4a Produced from Executing the JSL ImageToDataTable JSL Script



Figure 4a2(a) displays the data table of pixel coordinates and red, green, blue (RGB) colors that were transformed into hue, lightness, saturation (HLS) colors and grey-scale intensity (I) values. In other words, the data table gives a numerical representation of the image shown on the right in Figure 4a2(b) using JMP's Graph Builder.

Figure 4a2: Selected Records of the Data and Graph Builder Plot of Figure 4a



To manually reconstruct Figure 4a2(b) from the active data table in Figure 4a2(a), do the following steps:

1. Launch Graph Builder (**Graph > Graph Builder**)
2. Drag and Drop the **X** and **Y** columns into the X and Y axis drop zones, respectively
3. Select the **Points** element icon (📍)
4. Double-click the **Y** axis and check the **Reverse Order** box
5. Drag and Drop column **I** into the **Color** drop zone
6. Right-click the **Legend** scale (**Smooth**)
7. Select **Gradient**
8. Change the color theme to **Sequential**
9. Check the **Reverse Scale** box to flip the color values so that they match the original image
10. Click **OK** to apply the settings to the plot.

The following JSL commands produce the data table and Graph Builder display of Figure 4a2.

```
// Convert rgb to gray-scale (intensity) matrix
i = 0.3*r + 0.59*g + 0.11*b;
// Get the pixel values as JSL colors then convert to hue, lightness and saturation
// HLS colors are in normalized color space (0.0-1.0)
jsslColors = img << getPixels();
{h, l, s} = ColorToHLS(jsslColors);
// Get the dimensions of the image/matrices
numRows = nrow(r);
numCols = ncol(r);
// Create a data table
dt = New Table("GSW CT Image Data",
  newColumn("X", set values(repeat(1::numCols, numRows))),
  newColumn("Y", set values(shape(repeat(1::numRows, numCols)`, numCols, numRows))),
```

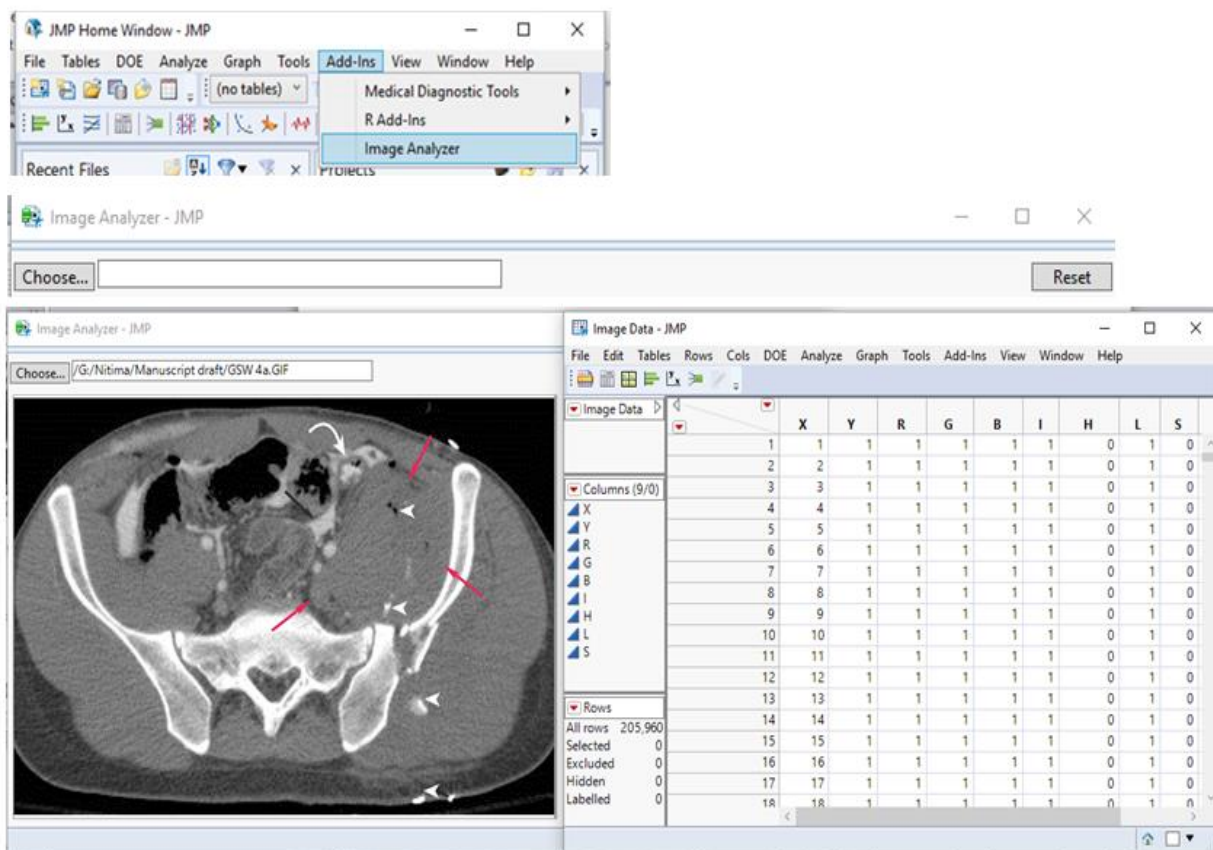
```

newColumn("r", set values(r)),
newColumn("g", set values(g)),
newColumn("b", set values(b)),
newColumn("i", set values(i)),
newColumn("h", set values(h)),
newColumn("l", set values(l)),
newColumn("s", set values(s))
);
// Produce Graph Builder plot of CT Image
Graph Builder( Size( 579, 500 ), Variables( X( :X ), Y( :Y ), Color( :i ) ),
Elements( Smoother( X, Y, Legend( 3 ) ), Points( X, Y, Legend( 4 ) ) ),
SendToReport( Dispatch( {}, "Y", ScaleBox, {Reversed Scale} ),
Dispatch( {}, "400", ScaleBox, {Legend Model( 4, Properties( 0,
{gradient( {Color Theme( "White to Black" }, Reverse Labels( 1 ) )} )
) } ) ) );

```

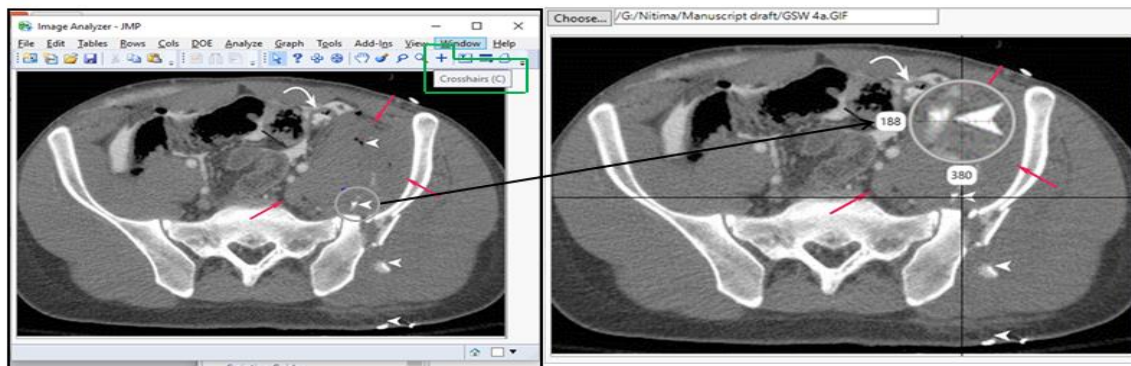
Figure 4a3 shows another way of generating the data table and graph by using the Image Analyzer Add-in of Ponte [7].

Figure 4a3: Open Image of Figure 4a using the Image Analyzer Add-In Source: Ponte (2015),
<https://community.jmp.com/docs/DOC-7181>.



The crosshairs tool (+) in Figure 4a4 locates specific points on the image that can be used to calculate distances between points in graphs and identify objects. Specific sections of interest from the image such as the direct wound tract sign (Q15, arrowheads) can be viewed more closely with the crosshairs tool. A magnified view of the X-Y coordinates shows where the vertical (Y) and horizontal (X) axis lines intersect. The subset table below the images shows the row with the pixel, RGB, and HLS data of the crosshairs.

Figure 4a4: Image of Figure 4a using the Crosshairs Tool



The crosshairs tool magnifies the view of the image selection. Also shows the X-Y coordinates (380,188) of the section of interest (Direct Wound tract sign, Q15, outlined by hematoma, bullet and bone fragments).

Row of the crosshairs X-Y coordinates shows the data from the data table record

X-Y Coordinates of Crosshairs Selection - JMP										
Rows		X	Y	R	G	B	I	H	L	S
All rows	1	1	380	188	0.4	0.501960784313726	0.4	0.460156862745098	0.333333333333333	0.450980392156863
Selected	0									
Excluded	0									

In addition to the crosshairs tool, which pinpoints specific points within a circular area, other point-selection tools are available. The Arrow cursor () and Brushing tool () select points within a rectangular area. The Lasso tool () selects points within irregularly-shaped areas. Holding the Shift or Ctrl keys, clicking and dragging the selected sections of the image also highlights the corresponding rows of the data table. The size of the selection rectangle of the Brushing tool can be changed by holding down the ALT key and click and drag for Windows (or hold down the OPTION key and click and drag for the Macintosh). These features categorize image selections into objects for further analysis and visual data mining.

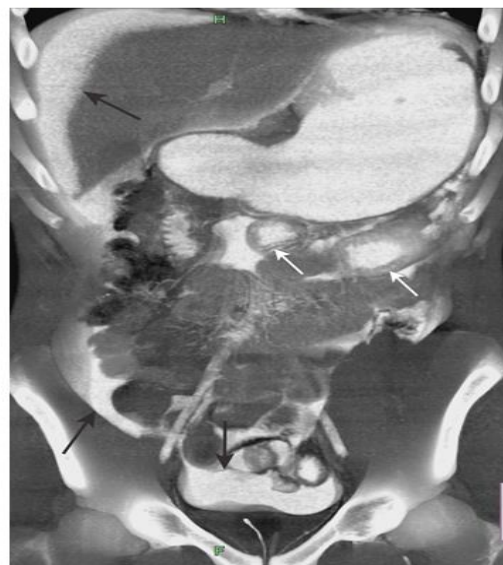
Figure 4b shows the Coronal (front-back) Gunshot wound to left pelvis with rectal contrast material extravasation for the same patient shown in Figure 4a.

Figure 4b: Coronal Image from Saksobhavivat et al. (2016) of Penetrating GI Tract Injury (Reprinted with permission from the European Society of Radiology)

European Radiology, pp 1-14 , First online: 16 March 2016

Diagnostic accuracy of triple-contrast multi-detector computed tomography for detection of penetrating gastrointestinal injury: a prospective study

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The Image Analyzer reproduces the data table and Graph Builder image of the coronal view in Figure 4b1.

Figure 4b1: Selected Records of the Data and Graph Builder Plot of Figure 4b

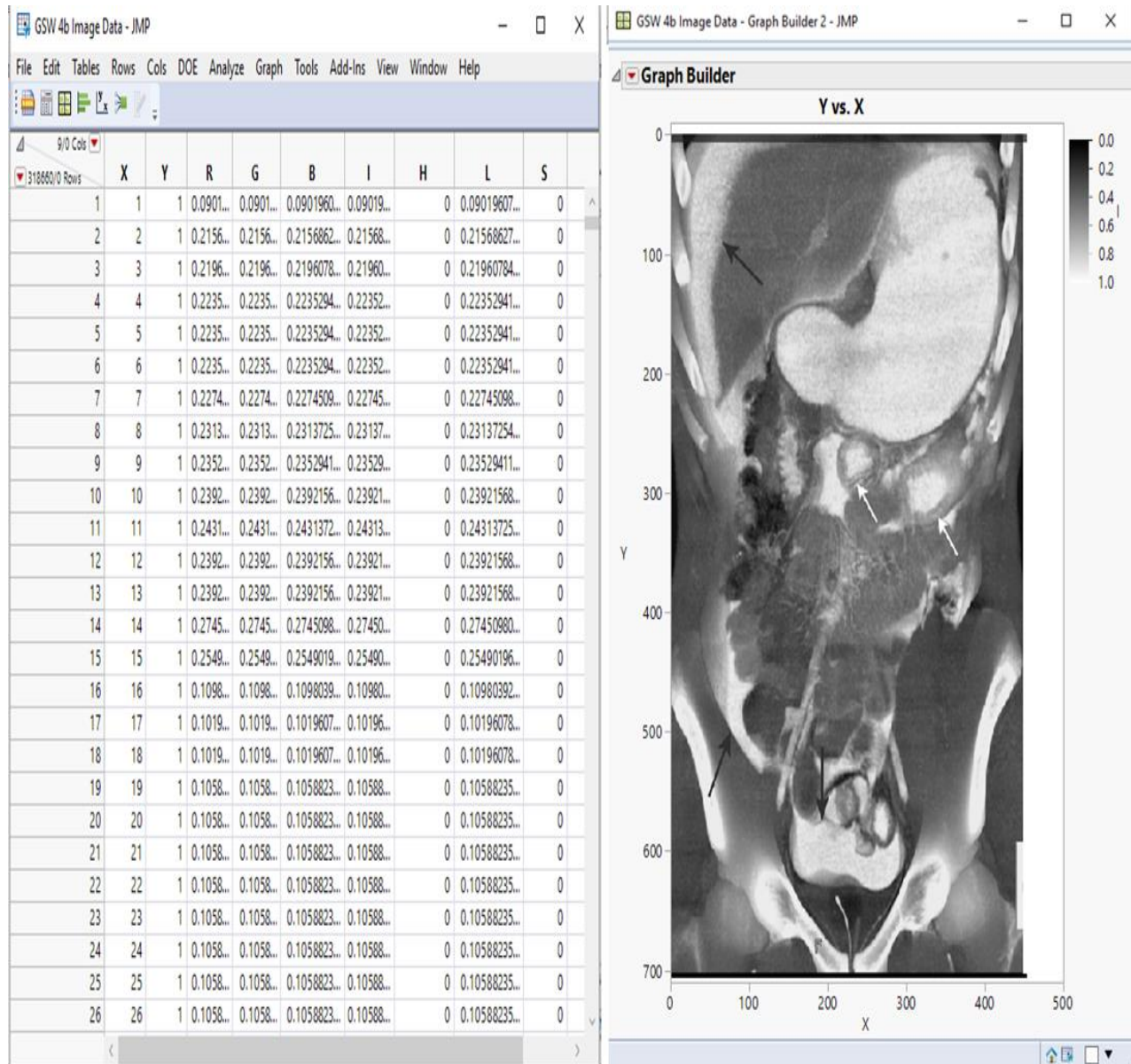
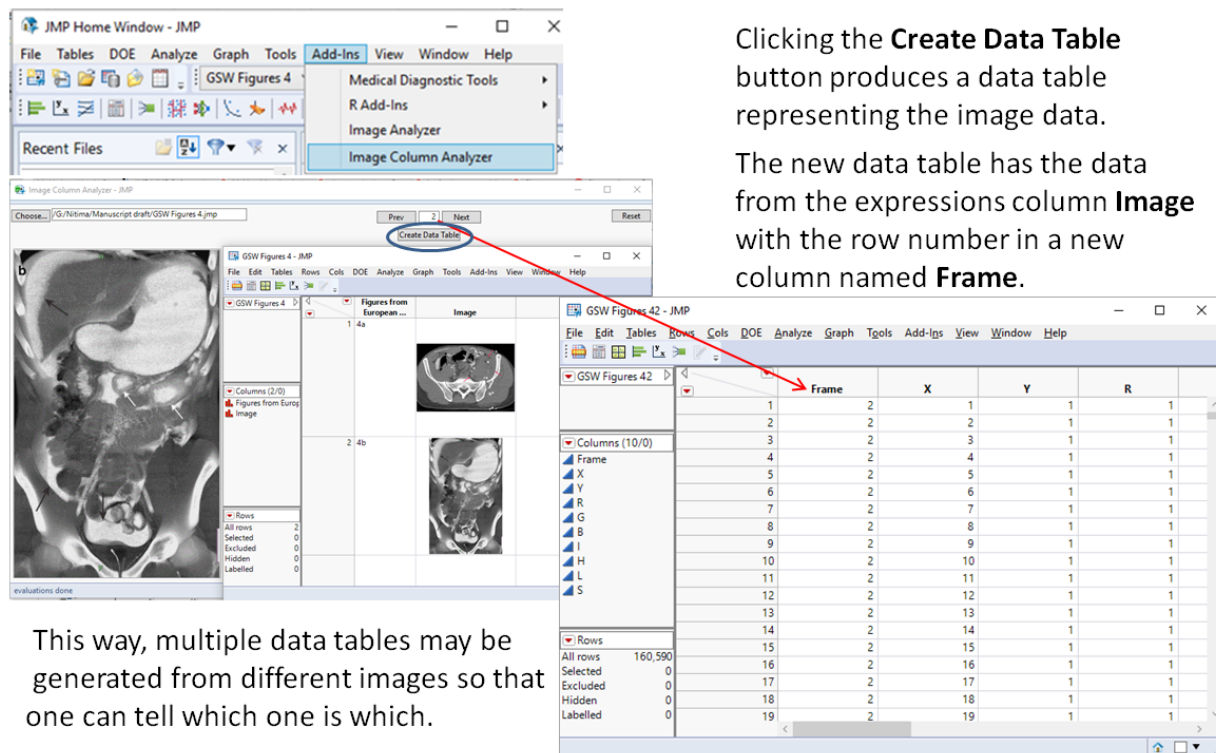


Figure 5 uses the Image Column Analyzer add-in, Ponte [12], to open images stored as expression columns in a JMP data table (Hales, [5,6]). Expressions columns allow pictures, matrices, lists, and other objects to be added into JMP data tables. When the **Create Data Table** button was clicked, a data table representing the image data was created.

The new data table name has a new column with the row number read from the original JMP data table. This feature is useful whenever multiple CT image frames of the same body region/section (or anatomical plane) are saved in rows of the data table. This way, multiple data tables of each image can be generated that tells which frame the images came from.

Figure 5: Example using Image Column Analyzer add-in to open images stored in an expression column of a JMP data table. Source: Ponte (2016), <https://community.jmp.com/docs/DOC-9901>



Multiple Data Tables output from clicking the **Create Data Table** button may be appended together to form the GSW Figures data table in Figure 6.

Figure 6: Image Data output from the Image Column Analyzer and Concatenated into bigger JMP data table.

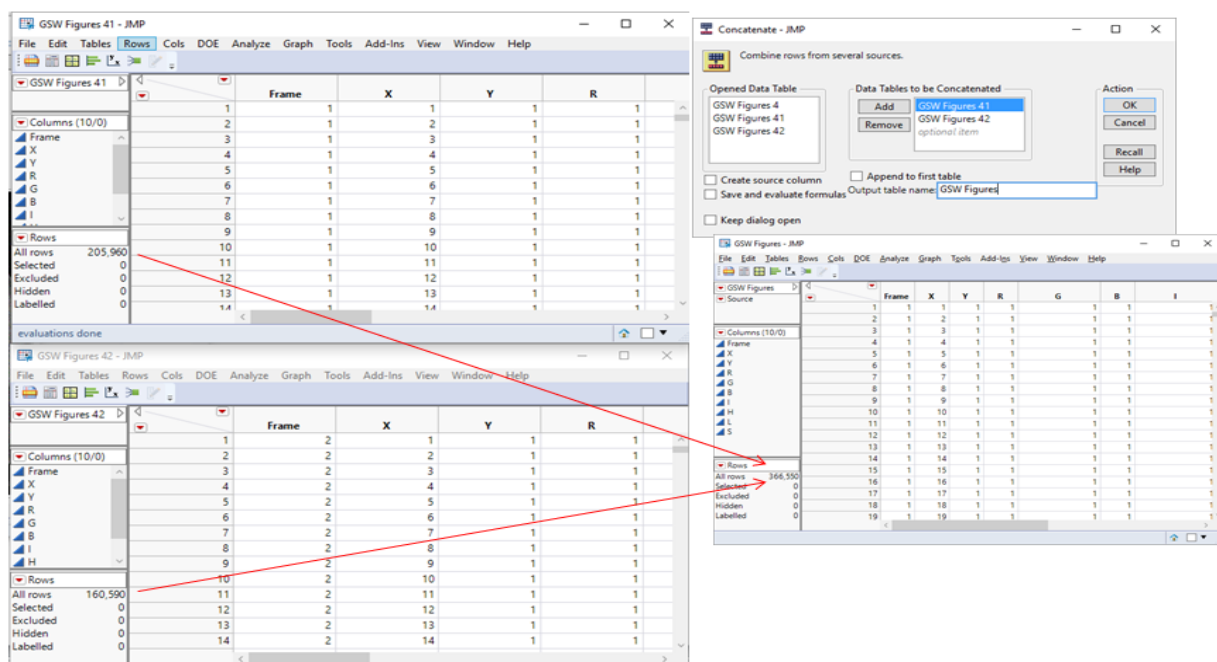
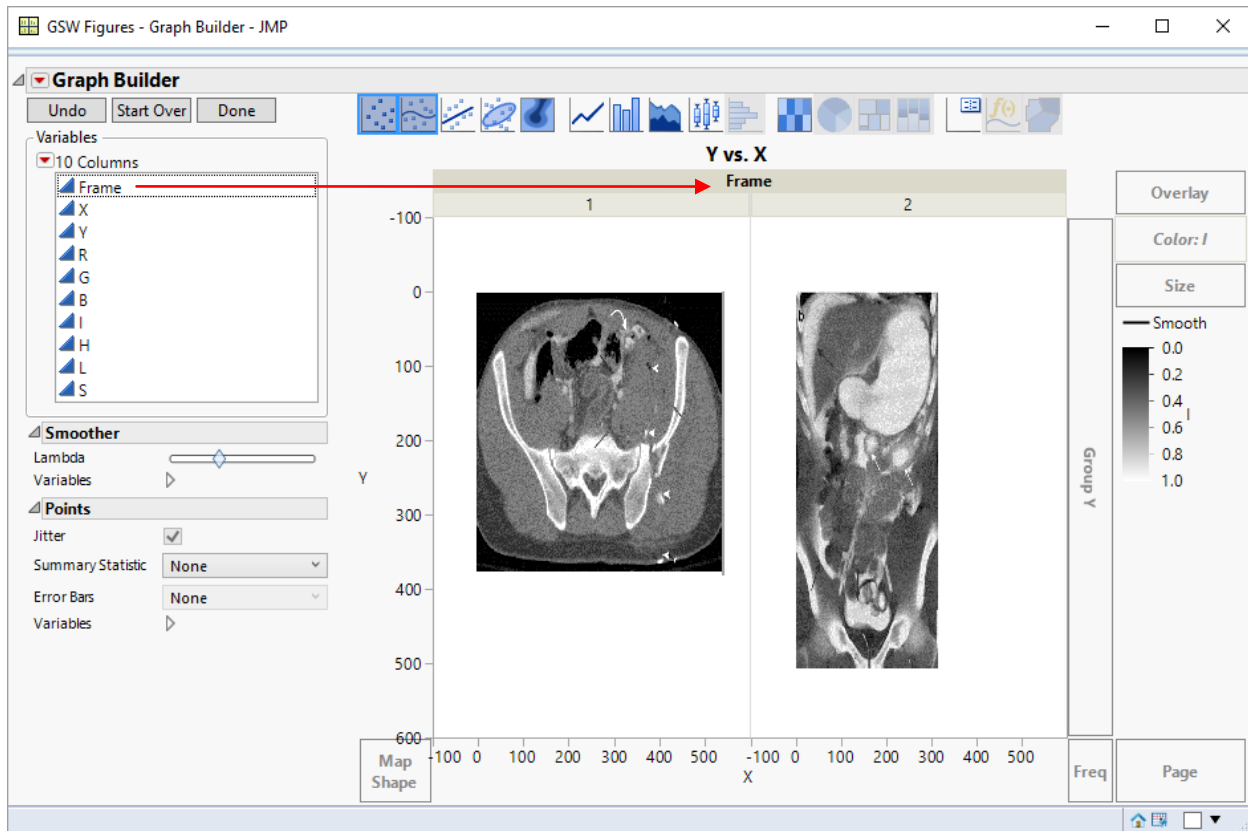


Figure 7 shows a Graph Builder plot of rearranged displays from multiple image frames. Using the combined Data Table from Figure 6, the plot can be made by repeating the steps used in producing Figure 4a2, and dragging and

dropping **Frame** into the Group X zone (for viewing horizontally). **Frame** can also be dragged and dropped into the Group Y zone (for viewing vertically). This feature allows multiple frames of images to be displayed into a single Graph Builder plot.

Figure 7: Graph Builder Plot of Data from Figure 6 with the Frame placed into the Group X zone.



REPLICATING JMP®'s IMAGING FUNCTIONALITY WITH SAS®

SAS can also be used to replicate some of the image functionality of JMP. The SAS code below creates a SAS dataset of the image-pixel values and RGB, HSL color schemes using techniques described by Watts [14] and others.

```

/*****
Program: Convert Image file to raw data with RGB colors
Purpose: This program opens a jpg, gif, png, bmp image data file
and converts the pixel values into a SAS dataset. A second program (RGBHex.sas)
converts the decimal RGB color to HEX which SAS can use to assign colors to X-Y
coordinates in another column in a raw_color SAS dataset. A third program
recreates the image using the gdraw option of the Data Set Graphical Interface
(DSGI).

Author: Melvin Alexander

INPUT X: path where the images (in png, jpg, bmp, or gif format) are stored for
Reference (4) defined as macro variable %fs
OUTPUT: Datasets raw, raw_color, and DSGI images Figs 4a, and 4b
References:
(1) Perry Watts, (2002), "Advanced Programming Techniques for Working with Color in
SAS(R)Software", SUGI 29 Proceedings,
(2) H-P Chen, http://www2.sas.com/proceedings/sugi31/056-31.pdf
(3)
https://support.sas.com/documentation/cdl/en/graphref/63022/HTML/default/viewer.htm#a0
02184394.htm#a002184522
(4) N. Saksobhavivat et al. (2016), "Diagnostic Accuracy of Triple-contrast Multi-

```

```

detector Computed Tomography for Detection of Penetrating Gastrointestinal
Injury: A Prospective Study", European Radiology.published online 16March2016,
http://link.springer.com/article/10.1007/s00330-016-4260-3.
*****/

/* CONVERT JPG, GIF, PNG, BMP IMAGE DATA INTO PIXEL VALUES IN A SAS DATASET */
%LET WIDTH=200;
%LET HEIGHT=100;
%LET DATA_BEGIN = 200000;
%LET FS = "P:\MY SAS FILES\IMG4B.PNG" ; /** FIG 4B FROM REF(4) **/
/* CONVERT INTEGER 0--255 TO 2 DIGIT HEX 00-FF */
%MACRO HEX2(N);
  %LOCAL DIGITS N1 N2;
  %LET DIGITS = 0123456789ABCDEF;
  %LET N1 = %SUBSTR(&DIGITS, &N / 16 + 1, 1);
  %LET N2 = %SUBSTR(&DIGITS, &N - &N / 16 * 16 + 1, 1);
  &N1&N2
%MEND HEX2;
/* CONVERT RGB TRIPLET (R,G,B) TO SAS COLOR IN
  HEXADECIMAL. THE R, G, AND B PARAMETERS ARE INTEGERS
  IN THE RANGE 0--255
*/
%MACRO RGB(R,G,B);
  %CMPRES(CX%HEX2(&R)%HEX2(&G)%HEX2(&B))
%MEND RGB;
DATA RAW;
INFILE &FS RECFM = F LRECL = 1 /* FIRSTOBS = &DATA_BEGIN */ ;
DO Y = 1 TO &HEIGHT ; DO X = 1 TO &WIDTH ;
INPUT R PIB1. G PIB1. B PIB1.;
/* CONVERT BYTES TO DECIMAL 0-255 */
I = 0.3*R + 0.59*G + 0.11*B ;
/* COMPUTE AVERAGE "GREY" LEVEL */
OUTPUT; END; END;RUN;
DATA RAW_COLOR_4B;
SET RAW;
RR=PUT(R,HEX2.); GG=PUT(G,HEX2.); BB=PUT(B,HEX2.);
/* CREATE AS A SAS RGB COLOR */
/* CHANGE YOUR RGB VALUES HERE */
SASRGB ="CX"||RR||GG||BB;
%LET SASCOL = SASRGB ;
RUN;

```

Table 2 shows selected records of the SAS dataset that translate the X-Y pixel coordinates, RGB, and HSL color system values for the axial image of Figure 4a.

Table 2: Selected Records of the raw_color_4a SAS Dataset for Fig 4a

RAW_COLOR_4A													
	y	x	r	g	b	i	rr	gg	bb	sasrgb			
1	1	1	137	80	78	96.88 89	50	4E		CX89504E			
2	1	2	71	13	10	30.07 47	00	0A		CX47000A			
3	1	3	26	10	0	13.7 1A	0A	00		CX1A0A00			
4	1	4	0	0	13	1.43 00	00	0D		CX00000D			
5	1	5	73	72	68	71.86 49	48	44		CX494844			
6	1	6	82	0	0	24.6 52	00	00		CX520000			
7	1	7	1	118	0	69.92 01	76	00		CX017600			
8	1	8	0	1	4	1.03 00	01	04		CX000104			
9	1	9	0	0	0	5.94 08	06	00		CX080600			
10	1	10	0	0	60	6.6 00	00	3C		CX00003C			
11	1	11	180	31	175	91.54 B4	1F	AF		CXB41FAF			
12	1	12	0	0	0	0 00	00	00		CX000000			
13	1	13	1	115	82	77.17 01	73	52		CX017352			
14	1	14	71	66	0	60.24 47	42	00		CX474200			
15	1	15	174	206	28	176.82 AE	CE	1C		CXAECE1C			
16	1	16	233	0	0	69.9 E9	00	00		CXE90000			
17	1	17	0	4	103	13.69 00	04	67		CX000467			
18	1	18	65	77	65	72.08 41	4D	41		CX414D41			
19	1	19	0	0	177	19.47 00	00	B1		CX0000B1			
20	1	20	143	11	252	77.11 8F	0B	FC		CX8F0BFC			
21	1	21	97	5	0	32.05 61	05	00		CX610500			
22	1	22	0	0	9	0.99 00	00	09		CX000009			
23	1	23	112	72	89	85.87 70	48	59		CX704859			
24	1	24	115	0	0	34.5 73	00	00		CX730000			
25	1	25	18	116	0	73.84 12	74	00		CX127400			
26	1	26	0	18	116	23.38 00	12	74		CX001274			
27	1	27	1	222	102	142.5 01	DE	66		CX01DE66			
28	1	28	31	120	0	80.1 1F	78	00		CX1F7800			
29	1	29	0	255	165	168.6 00	FF	A5		CX00FFA5			
30	1	30	73	68	65	69.17 49	44	41		CX494441			
31	1	31	84	120	94	106.34 54	78	5E		CX54785E			
32	1	32	236	221	7	201.96 EC	DD	07		CXECDD07			
33	1	33	220	102	87	136.75 DC	66	57		CXDC6657			
34	1	34	89	239	125	181.46 59	EF	7D		CX59EF7D			

Table 3: Selected Records of the raw_color_4b SAS Dataset for Fig 4b

RAW_COLOR_4B -

<

Figures 8 and 9 recreate images of Figures 4a and 4b using the Data Set Graphics Interface (DSGI) SAS code. See Chen [2] for more information.

Figure 8: Recreated Image of Fig 4a

```

* IMAGE 4A ;
GOPTIONS RESET=ALL DEVICE=PNG
  FTEXT="ALBANY AMT/BOLD" HTITLE=1.25
  HSIZE=4.2IN VSIZE=5.5IN;
TITLE "Image of Figure 4a, European Radiology (2016)
";
TITLE2 "Reprinted with permission from the" ;
TITLE3 "European Society of Radiology" ;
DATA IMAGE;
  RC=GINIT() ;
  RC=GRAPH("CLEAR") ;
  RC=GDRAW("IMAGE", "P:\MY SAS FILES\IMG4A.PNG",
    5, 5, 88, 88,"FIT");
  RC=GRAPH("UPDATE") ;
  RC=GTERM() ;
RUN;
QUIT;

```

Image of Figure 4a, European Radiology (2016)
Reprinted with permission from the
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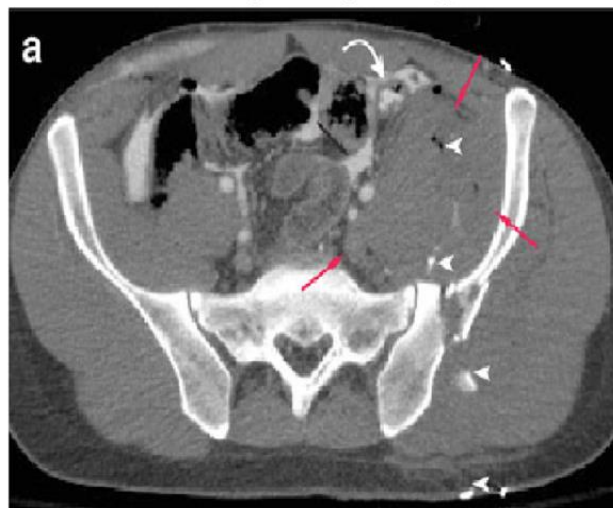


Figure 9: Recreated Image of Fig 4b

```

* IMAGE 4B ;
GOPTIONS RESET=ALL DEVICE=PNG
  FTEXT="ALBANY AMT/BOLD" HTITLE=1.25
  HSIZE=4.2IN VSIZE=5.5IN;
TITLE "Image of Figure 4b, European Radiology (2016)
";
TITLE2 "Reprinted with permission from the " ;
TITLE3 "European Society of Radiology " ;
DATA IMAGE;
  RC=GINIT() ;
  RC=GRAPH("CLEAR");
  RC=GDRW("IMAGE", "P:\MY SAS FILES\IMG4B.PNG",
    5, 5, 90, 90, "FIT");
  RC=GRAPH("UPDATE");
  RC=GTERM() ;
RUN;
QUIT;

```

Image of Figure 4b, European Radiology (2016)
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Because images cannot be added to SAS datasets the way they can be added in a JMP Expressions column, Figure 10 shows how to emulate the JMP functionality of Figure 5 by writing the data to a pdf file with SAS' ODS and PROC REPORT. The **POSTIMAGE** style attribute embeds images into a PROC REPORT column based on the value of the **Figures** variable in the **GSW_Figures** dataset. The output may be saved in RTF, HTML, or PDF formats.

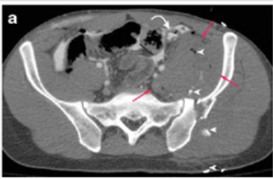
Figure 10: SAS Equivalent of JMP Expressions Column (in Figure 5) with Images 4a and 4b written as a PDF File using PROC REPORT and ODS. Note that image frames appear vertically rather than horizontally.

```

/*****
Program: Write Image to a PROC REPORT pdf file
Purpose: This adds images to a proc report written to a pdf file that
emulates
Images added to a JMP Expressions column in a JMP Data Table.
Author: Melvin Alexander
INPUT X: path where the images (in png, jpg, bmp, or gif format) are
stored.
OUTPUT: PDF with images 4a and 4b as a separate column next to SAS
Dataset
REFERENCES:
"Sample 46552: Embed images in a PROC REPORT table",
http://support.sas.com/kb/46/552.html
*****/
ODS PDF FILE='P:\MY SAS FILES\FIGSPDF.PDF';
DATA GSW_FIGURES;
INPUT FIGURES $ ;
DATALINES;
4A
4B
;
RUN;

PROC REPORT DATA=WORK.GSW_FIGURES NOWD SPANROWS
  STYLE(REPORT)=(RULES=NONE FRAME=VOID)
  STYLE(COLUMN)=(FONT_FACE=ARIAL FONT_SIZE=12PT VJUST=CENTER) ;
  COLUMN FIGURES IMAGE ;
  DEFINE FIGURES / 'Figures from European Radiology (images arranged
vertically)' GROUP ORDER=DATA STYLE(COLUMN)=(CELLWIDTH=1.2IN);
  DEFINE IMAGE / 'Image' COMPUTED CENTER;
  COMPUTE IMAGE /CHAR;
  IF FIGURES='4A' THEN DO;
    CALL DEFINE(_COL_, 'STYLE', 'STYLE=[POSTIMAGE="P:\MY SAS
FILES\IMG4A.PNG"]');
  END;
  ELSE DO;
    CALL DEFINE(_COL_, 'STYLE', 'STYLE=[POSTIMAGE="P:\MY SAS
FILES\IMG4B.PNG"]');
  END;
  ENDCOMP;
RUN;
ODS PDF CLOSE;
ODS HTML CLOSE;

```

The SAS System	
Figures from European Radiology (images arranged vertically)	Image
4a	
4b	

SUMMARY AND CONCLUSIONS

Medical imaging involves techniques for creating visualizations of internal body functions, organs, and tissues that help diagnose and treat patients with medical and injuries.

JMP has numerous tools for doing image segmentation and additional analytics such as:

- Converting pixel coordinate data into quantitative measures in data tables that identify specific edges, boundaries, and body regions of interest from images using JSL, Image Analyzer add-ins, and the crosshairs tool
- Modifying the gray scale or color gradients version of an image to identify edges, boundaries, regions, movement and many other important criteria within the Graph Builder
- Establishing relationships and associations between variables, features and time, using the Expressions column. Image frames of the same patients taken at different time points which allow image viewers to pattern-match signs; and to identify medical conditions, indicators, or markers of injuries at specific organ sites and body regions. These markers are useful in deciding treatment options for patients.

SAS replicates many of JMP's imaging functionalities as well as takes advantage of additional, advanced Visual Analytic capabilities.

Ventner and Stein [15], Kobiellus [16], and Nisbet, Elder, and Miner [17] provide additional thoughts about emerging trends and future of imaging analytics that JMP and SAS continues to explore.

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CONTACT INFORMATION

Your comments and questions are valued and encouraged. Contact the author at:

Melvin Alexander
Social Security Administration
6401 Security Blvd., East High Rise Building (4-A-6)
Baltimore, MD 21235
Phone: (410) 966-2155
Fax: (410) 597-0354
E-mail: Melvin.Alexander@ssa.gov

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