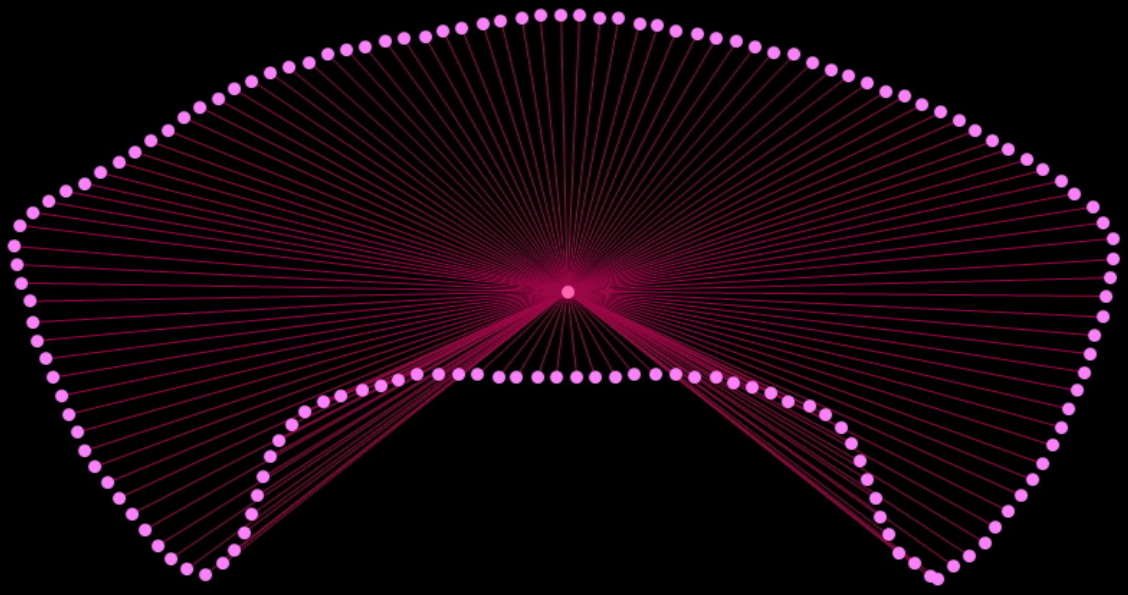


GMTP

Ver. 2.1

manual

Geometric Morphometrics Tools Package

By:
Siavash Taravati

Dr. Jamshid Darvish
Professor-Biology Department-Ferdowsi University of Mashhad, Iran

Acknowledgement

We’d like to especially thank Mr. Rohollah Siyahsarvi for his kind help in basic technical issues regarding geometric morphometrics.

Introduction:

Geometric Morphometrics Tools Package (GMTP) version 2.1 is a program for data conversion, size calculation, shape drawing and image cropping for outline data.

This program has the below abilities:

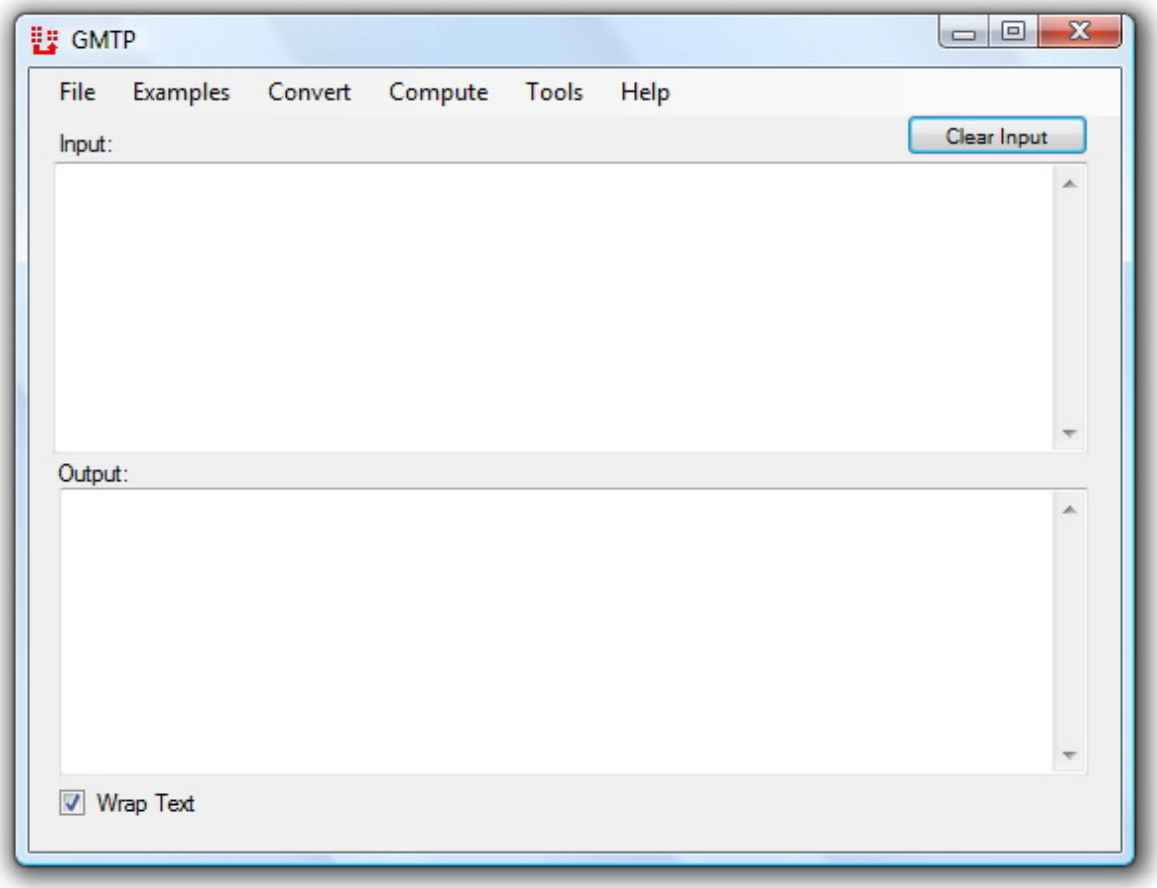
1- Examples: Contains example data for tpsDig curve data, EFA .out file and NTS aligned specimens.
2- Data Convertion:
    a. tps to PAST, EFA, Morpheus, CSV
    b. NTS(only aligned specimens) to CSV
    c. EFA(harmonics, .out) to PAST
    d. EFA(Reproduced Outline, .out) to PAST
3- Size Calculation
    a. Centroid Position
    b. Centroid Size
    c. Area: Automatically closes the curve for accurate calculation
    d. Perimeter: Asks user whether to calculate close or open curve. If the curve is an open curve, then the program adds the distance between first and last point to the total distance.
4- Crop by coordinates: Crops the original image by shape coordinates
5- Visualizer: Draws the shapes of a tps file.
6- Manual superimpose: Superimposes the first two shapes of input data and gives the user the ability to resize, translate and rotate the front shape in reference to its reference shape.
7- Geometric algorithms: Draws creative geometric shapes according to the input data.

This is a concise but straightforward manual for using GMTP version 2.0. There are a few buttons which can do data transformations with just a mouse click. This ability tremendously reduces the amount of time and effort needed to do the task done manually. In addition, it reduces the errors which usually occur during the manual transformations. For more accuracy, in this manual the data structure of every format has been described. GMTP gives users the ability to use a wide range of options for visualizing the standardized shapes including centroid, centroid radial lines, maximum and minimum line from centroid and the line connecting farthest points from each other in different colors. Crop by Coordinate is another ability of GMTP in which the shape is used to crop the original image from its surroundings. Different size calculations (Centroid Size, Area, Perimeter) are provided with this version for outline data.

This version of GMTP deals with Outline data (except NTStoCSV for aligned specimens), so if you are working with outline data, this program will be a very handy tool for you.

Environment:

GMTP ver 2.1 has a simple environment with two textboxes and six converter buttons and several menus. The first textbox is the input textbox and the lower textbox is the output textbox from which you can see the results of conversion.



How to load data:

The first step using the software is to load data into it. For that, you have two options: 1) Paste data into the input textbox by pressing ctrl+v or right-click in the inputbox and choosing paste 2) use menu File=> Open and choose your desired text file and click Open button, after that the software automatically loads the data of that file into the input textbox.

How to save data:

Similar to previous section, you have two options: 1) Copy the output data from the output textbox by pressing ctrl+A (select all) and then either pressing ctrl+C or doing a right-click on the selected text and choosing copy from the context menu. Then you can paste your copied data to every text editor software 2) Use menu File=> Save As and navigate to the destination folder and choose the name of your file and press Save button.

How to convert data:

There are few buttons on the program form which you can convert your data. For converting data, first you have to load data into the input textbox. After that you have to only click the button with the desired destination format. For example if you have loaded TPS outline file into the input textbox, you can convert it to 4 other formats namely: PAST, EFA, Morpheus and CSV by clicking their button. The result will appear in the output textbox.

Section One: Data formats

Here the data formats which GMTP recognizes and can handle are described.

TPS:
Outline data which has been created by TPSDig software has a specific structure which can be recognized GMTP. Please read the notes after (') in each line which are necessary guidelines for making your data work with GMTP. This is important only if you have modified your data manually.

`LM=n` ' n should be 0
`CURVES=n` ' n should be 1 or `OUTLINE=1`
`COMMENT=String` 'String = any text with white spaces; can be placed anywhere
`OUTLINES=n` ' n should be 1 or `CURVES=1`
`POINTS=n` 'n can be any integer
`150.00000 280.00000` 'coordinates of point 1 (x_1, y_1)
`138.00000 271.00000` 'coordinates of point 2 (x_2, y_2)
...
`143.00000 265.00000` 'coordinates of point n (x_n, y_n)
`IMAGE=String` 'string= any file name with extension (ex. File.jpg), white space is allowed
`ID=0` 'any integer or text without white space. Modification of this number is not recommended because it is an auto-increment variable.
`VARIABLES=String ‘ Name and content of variables`
`SCALE=n` 'n= any decimal number (ex. 0.0054)

Extra items within the data will be ignored or result in an error. If you have extra items in the text, you can first delete them manually with a text editor and then load the modified text into the GMTP.

What to do & not to do about .tps format:
For achieving the successful result you should use correct input format and you should
- **Not** use both CURVES and OUTLINES data for each specimen (image)

- **Not** use multiple CURVES or OUTLINES for each image (CURVES&OUTLINES should be =1)

- **Not** modify the .tps file spaces and line breaks manually unless you know what you are doing. Doing that may cause error in text conversion process.

A sample of TPS outlines data (Curve):

LM=0	88.00000 283.00000
CURVES=1	70.00000 267.00000
COMMENT=Specimen1 outline	53.00000 249.00000
POINTS=50	53.00000 227.00000
418.00000 118.00000	61.00000 204.00000
435.00000 135.00000	70.00000 181.00000
450.00000 154.00000	80.00000 159.00000
464.00000 174.00000	95.00000 141.00000
476.00000 195.00000	113.00000 125.00000
484.00000 218.00000	133.00000 120.00000
490.00000 241.00000	144.00000 140.00000
485.00000 262.00000	150.00000 164.00000
464.00000 275.00000	163.00000 183.00000
444.00000 288.00000	185.00000 192.00000
424.00000 302.00000	209.00000 198.00000
402.00000 313.00000	232.00000 202.00000
380.00000 323.00000	256.00000 206.00000
358.00000 332.00000	281.00000 207.00000
335.00000 339.00000	304.00000 202.00000
312.00000 346.00000	328.00000 197.00000
288.00000 352.00000	351.00000 191.00000
264.00000 353.00000	373.00000 182.00000
240.00000 349.00000	386.00000 161.00000
216.00000 345.00000	394.00000 138.00000
193.00000 339.00000	411.00000 121.00000
169.00000 333.00000	IMAGE=203.JPG
147.00000 325.00000	ID=0
126.00000 313.00000	VARIABLES=Area=15.904
106.00000 299.00000	SCALE=0.019371
Continued on next column=>	

EFA (.out):

After doing analysis with EFA (Elliptic Fourier Analysis) software, you will receive an output file with the default extension (.out).

Sample data:

Input file: C:\USERS\USER1\DOCUME~1\ELLIPT~1\AA.DTA
Label: Title of you file

N points = 150, N harmonics = 15
Invariant to size (area)
Area = 191.393
Invariant to location
Centroid of outline = 1643.38,1069.79
Invariant to rotation
Rotation angle (radians) = -0.00428824

Elliptic Fourier coefficients:

Zeroth harmonic:
A0=-0.0023454, C0=0.00252627

Coefficients for harmonics:

	A	B	C	D
1	0.84603703	0.533124089	-0.239522591	0.380108505
2	-0.0441602804	0.0226902012	-0.0824214518	-0.169465259
3	-0.00394586055	0.0364991948	-0.137709826	-0.0164170079
4	-0.034461204	-0.0289609842	-0.0181814674	0.0188165139
5	-0.0176598057	0.00626553735	-0.00961191952	-0.0351186357
6	0.00396236079	-0.00936307106	-0.031455867	-0.00814476237
7	-0.000975389034	0.000153901899	-0.011916806	0.0138482079

8	-0.00154580304	0.000443922239	-0.000583542511	0.00341604301
9	-0.00531481393	0.0115964916	-0.00615508761	-0.00348898396
10	0.00342499954	0.00278517022	-0.0103251981	0.00634928653
11	-0.00682497257	0.000283707952	0.00106660731	0.000444231409
12	-0.000761005329	0.00294012111	-0.00396916363	-0.00166708499
13	6.34739772e-05	0.000588337483	-0.00308957975	0.00203714753
14	0.00301377359	0.000116416566	-0.000223065057	0.00160011929
15	-0.000308533985	-0.000220103437	0.000747652375	5.01438008e-05

GMTP reads the EFA data and produce a PAST file with harmonics of each specimen.

NTS:

NTS format which is produced by TPSRelw from landmark data is also supported by GMTP but currently it only converts the data of aligned specimens. The general structure of NTS is mentioned below:

"Aligned specimens
"(from tpsRelw, ver. 1.42)
" Alignment scaling method = unit centroid size
" Alignment projection method = orthogonal
1 **10L** **12** 0
0 1 2 3 4 5 6 7 8 9 10
3.48712795657773E-001 -2.27293368995552E-001 5.32663667823830E-001 1.03817860141256E-001 -2.04718644477871E-003
2.90271940600923E-001 -5.17133817174176E-001 1.03818857532850E-001 -3.42992208612809E-001 -2.27292734887298E-001
-1.92032512498394E-002 -4.33225543921792E-002
3.51544927332767E-001 -2.18878839928846E-001 5.32420301387639E-001 8.62320473724222E-002 3.26525141861013E-004
3.03689080634369E-001 -5.21422611879753E-001 8.54426449575243E-002 -3.42836741366974E-001 -2.17662378336751E-001
-2.00324006155397E-002 -3.88225546987185E-002
3.48607600130231E-001 -2.30803640406914E-001 5.22919961859777E-001 8.65647291170002E-002 -3.59327816610270E-003
3.20974547067451E-001 -5.09847216221409E-001 7.64833114120596E-002 -3.54465674964006E-001 -2.21347032496353E-001
-3.62139263849012E-003 -3.18719146932436E-002
3.68106844150975E-001 -2.11812458660083E-001 5.25426395014018E-001 7.96065705045005E-002 -1.35351998661409E-002
3.09546744337165E-001 -5.04140538512667E-001 8.86180935690261E-002 -3.62038423557832E-001 -2.16167098942064E-001
-1.38190772283537E-002 -4.97918508085450E-002
3.40813764303137E-001 -2.29834339839475E-001 5.32728411936872E-001 9.65647651470500E-002 -4.89583284045717E-003
3.08914459906704E-001 -5.12947629737511E-001 8.95769535369935E-002 -3.45860639389631E-001 -2.24720628354222E-001
-9.83807427240947E-003 -4.05012103970504E-002
3.59021152010470E-001 -2.25655702134432E-001 5.04167234658216E-001 8.54125215799259E-002 6.92584084248545E-003
3.19733386727681E-001 -5.29894605085638E-001 8.64920016493433E-002 -3.45396959276386E-001 -2.19038037630903E-001
5.17733685085220E-003 -4.69441701916157E-002
3.46157079347865E-001 -2.28255985951813E-001 5.32804916299272E-001 1.01244333274185E-001 -1.36682543483857E-002
2.98903102199093E-001 -5.10397278284501E-001 1.01668539244294E-001 -3.49300758788482E-001 -2.24687218613530E-001
-5.59570422576856E-003 -4.88727701522279E-002
3.57059819404520E-001 -2.16149956725552E-001 5.20374847500945E-001 8.95647032992244E-002 -2.94444808001781E-003
3.01963254586552E-001 -5.20736636429846E-001 8.86706297510748E-002 -3.60014052629659E-001 -2.13869519762506E-001
6.26047023405707E-003 -5.01791111487939E-002
3.40474553307012E-001 -2.26898686685460E-001 5.28678502807869E-001 8.77425279368062E-002 -5.93859095396248E-003
3.15210424649870E-001 -5.13769112916848E-001 8.80190995013738E-002 -3.46593990240607E-001 -2.30919339258113E-001
-2.85136200346312E-003 -3.31540261444769E-002
3.49899880444820E-001 -2.33283558728165E-001 5.29704904175252E-001 9.77274106575651E-002 -1.13743272870809E-002
2.97682825716657E-001 -5.12699800634784E-001 9.96506421425726E-002 -3.44928974144761E-001 -2.28358284129839E-001
-1.06016825534464E-002 -3.34190356587913E-002

Destination formats:

EFA:

EFA format is very simple. The first line is the description of the data; after that at the beginning of each specimen, the first number is the number of points for that specimen following the x & y coordinates for each point. For more accuracy, GMTP formats the data in a way that is easy to read for human eye; it puts line breaks at the end of each specimen data as you can see in the sample data below. The advantage of that is the user can check the data with the original data whenever needed. In the below example the blue text is the label of the file and the red numbers are the number of points for each specimen. Other numbers are the coordinates. Sample Data:

Title of you file

150 1785 960 1791 965 1797 969 1803 974 1807 980 1812 986 1817 992 1821 998 1825 1004 1829 1011 1832 1018 1835 1025 1838 1032 1841 1039 1843 1046 1845 1053 1848 1060 1849 1068 1851 1075 1852 1082 1852 1090 1848 1096 1844 1102 1837 1107 1832 1112 1825 1116 1819 1120 1812 1124 1806 1127 1799 1131 1793 1135 1786 1138 1779 1141 1772 1144 1765 1146 1758 1149 1751 1152 1744 1154 1737 1157 1730 1160 1722 1161 1715 1163 1708 1165 1700 1166 1693 1168 1685 1169 1678 1171 1671 1172 1663 1174 1656 1174 1648 1175 1641 1175 1633 1175 1626 1174 1618 1173 1611 1172 1603 1170 1596 1169 1589 1167 1581 1166 1574 1165 1566 1163 1559 1162 1552 1160 1545 1157 1537 1155 1530 1153 1523 1150 1516 1147 1510 1143 1503 1140 1497 1136 1491 1131 1484 1127 1478 1123 1472 1119 1465 1115 1459 1111 1452 1108 1445 1104 1439 1100 1434 1095 1432 1087 1433 1080 1435 1073 1438 1066 1439 1058 1441 1051 1444 1044 1447 1037 1450 1030 1453 1023 1456 1016 1459 1009 1463 1003 1468 997 1472 991 1477 985 1482 979 1487 973 1492 968 1498 964 1505 962 1512 966 1516 971 1520 978 1523 985 1525 992 1527 999 1530 1007 1533 1013 1538 1019 1543 1024 1550 1028 1557 1030 1565 1032 1572 1034 1579 1036 1586 1038 1594 1038 1602 1038 1609 1038 1617 1037 1624 1037 1632 1037 1639 1037 1647 1037 1654 1037 1662 1037 1669 1038 1677 1038 1685 1038 1692 1037 1700 1037 1707 1035 1714 1033 1721 1031 1728 1028 1736 1026 1742 1023 1748 1018 1752 1012 1755 1005 1758 998 1761 991 1763 984 1766 977 1770 970 1776 966 1782 961

150 1919 952 1925 956 1931 960 1937 965 1942 970 1947 976 1951 982 1956 988 1960 994 1965 1000 1969 1006 1973 1013 1976 1020 1979 1026 1982 1033 1986 1040 1989 1047 1992 1053 1994 1061 1996 1068 1995 1075 1991 1082 1986 1086 1980 1091 1974 1096 1968 1100 1962 1104 1955 1108 1949 1112 1943 1116 1936 1120 1930 1124 1924 1128 1917 1132 1911 1136 1904 1138 1897 1141 1890 1144 1883 1147 1876 1149 1869 1151 1862 1153 1854 1155 1847 1157 1840 1159 1833 1160 1825 1162 1818 1164 1811 1166 1803 1167 1796 1168 1789 1169 1781 1169 1774 1168 1766 1168 1759 1166 1752 1164 1745 1163 1737 1161 1730 1160 1722 1159 1715 1158 1708 1157 1700 1156 1693 1153 1686 1151 1679 1149 1672 1146 1665 1144 1658 1141 1652 1137 1645 1134 1639 1130 1632 1127 1626 1123 1620 1118 1614 1113 1609 1108 1602 1104 1596 1101 1590 1096 1583 1093 1577 1089 1572 1084 1569 1077 1572 1070 1575 1063 1578 1056 1581 1049 1583 1042 1586 1035 1589 1028 1593 1022 1597 1016 1600 1009 1604 1002 1607 996 1611 989 1616 984 1621 978 1626 973 1631 967 1636 961 1642 958 1648 962 1654 967 1658 973 1661 980 1663 987 1666 994 1668 1001 1672 1008 1677 1013 1684 1016 1691 1018 1699 1020 1706 1022 1713 1023 1721 1024 1728 1025 1736 1026 1743 1026 1750 1026 1758 1026 1765 1026 1773 1026 1780 1026 1788 1026 1795 1026 1803 1026 1810 1025 1818 1025 1825 1025 1833 1025 1840 1024 1847 1023 1855 1021 1862 1019 1869 1016 1876 1014 1882 1010 1888 1006 1894 1000 1898 994 1901 987 1903 980 1906 973 1909 966 1913 960 1917 954

150 . . .

PAST:

PAST format is a little bit more complicated regarding the input of row and column labels. The first paragraph includes the labels of the columns (in green). At the beginning of the new line is the code of the color of that row (in red, in fact 1 account for red row color in PAST) and the second number (in blue) is the label of that row which has been extracted from IMAGE=file.* in the tps file. Note that when you converting EFA(.out) to PAST you'll not see the row labels in the output of GMTP because EFA input is very concise and force users to remove the description or label of the specimens.

. x1 y1 x2 y2 x3 y3 x4 y4 x5 y5 x6 y6 x7 y7 x8 y8 x9 y9 x10 y10 x11 y11 x12 y12 x13 y13 x14 y14 x15 y15 x16 y16 x17 y17 x18 y18 x19 y19 x20 y20 x21 y21 x22 y22 x23 y23 x24 y24 x25 y25 x26 y26 x27 y27 x28 y28 x29 y29 x30 y30 x31 y31 x32 y32 x33 y33 x34 y34 x35 y35 x36 y36 x37 y37 x38 y38 x39 y39 x40 y40 x41 y41 x42 y42 x43 y43 x44 y44 x45 y45 x46 y46 x47 y47 x48 y48 x49 y49 x50 y50 x51 y51 x52 y52 x53 y53 x54 y54 x55 y55 x56 y56 x57 y57 x58 y58 x59 y59 x60 y60 x61 y61 x62 y62 x63 y63 x64 y64 x65 y65 x66 y66 x67 y67 x68 y68 x69 y69 x70 y70 x71 y71 x72 y72 x73 y73 x74 y74 x75 y75 x76 y76 x77 y77 x78 y78 x79 y79 x80 y80 x81 y81 x82 y82 x83 y83 x84 y84 x85 y85 x86 y86 x87 y87 x88 y88 x89 y89 x90 y90 x91 y91 x92 y92 x93 y93 x94 y94 x95 y95 x96 y96 x97 y97 x98 y98 x99 y99 x100 y100 x101 y101 x102 y102 x103 y103 x104 y104 x105 y105 x106 y106 x107 y107 x108 y108 x109 y109 x110 y110 x111 y111 x112 y112 x113 y113 x114 y114 x115 y115 x116 y116 x117 y117 x118 y118 x119 y119 x120 y120 x121 y121 x122 y122 x123 y123 x124 y124 x125 y125 x126 y126 x127 y127 x128 y128 x129 y129 x130 y130 x131 y131 x132 y132 x133 y133 x134 y134 x135 y135 x136 y136 x137 y137 x138 y138 x139 y139 x140 y140 x141 y141 x142 y142 x143 y143 x144 y144 x145 y145 x146 y146 x147 y147 x148 y148 x149 y149 x150 y150

_1_201 1785 960 1791 965 1797 969 1803 974 1807 980 1812 986 1817 992 1821 998 1825 1004 1829 1011 1832 1018 1835 1025 1838 1032 1841 1039 1843 1046 1845 1053 1848 1060 1849 1068 1851 1075 1852 1082 1852 1090 1848 1096 1844 1102 1837 1107 1832 1112 1825 1116 1819 1120 1812 1124 1806 1127 1799 1131 1793 1135 1786 1138 1779 1141 1772 1144 1765 1146 1758 1149 1751 1152 1744 1154 1737 1157 1730 1160 1722 1161 1715 1163 1708 1165 1700 1166 1693 1168 1685 1169 1678 1171 1671 1172 1663 1174 1656 1174 1648 1175 1641 1175 1633 1175 1626 1174 1618 1173 1611 1172 1603 1170 1596 1169 1589 1167 1581 1166 1574 1165 1566 1163 1559 1162 1552 1160 1545 1157 1537 1155 1530 1153 1523 1150 1516 1147 1510 1143 1503 1140 1497 1136 1491 1131 1484 1127 1478 1123 1472 1119 1465 1115 1459 1111 1452 1108 1445 1104 1439 1100 1434 1095 1432 1087 1433 1080 1435 1073 1438 1066 1439 1058 1441 1051 1444 1044 1447 1037 1450 1030 1453 1023 1456 1016 1459 1009 1463 1003 1468 997 1472 991 1477 985 1482 979 1487 973 1492 968 1498 964 1505 962 1512 966 1516 971 1520 978 1523 985 1525 992 1527 999 1530 1007 1533 1013 1538 1019 1543 1024 1550 1028 1557 1030 1565 1032 1572 1034 1579 1036 1586 1038 1594 1038 1602 1038 1609 1038 1617 1037 1624 1037 1632 1037 1639 1037 1647 1037 1654 1037 1662 1037 1669 1038 1677 1038 1685 1038 1692 1037 1700 1037 1707 1035 1714 1033 1721 1031 1728 1028 1736 1026 1742 1023 1748 1018 1752 1012 1755 1005 1758 998 1761 991 1763 984 1766 977 1770 970 1776 966 1782 961

_1_202 1919 952 1925 956 1931 960 1937 965 1942 970 1947 976 1951 982 1956 988 1960 994 1965 1000 1969 1006 1973 1013 1976 1020 1979 1026 1982 1033 1986 1040 1989 1047 1992 1053 1994 1061 1996 1068 1995 1075 1991 1082 1986 1086 1980 1091 1974 1096 1968 1100 1962 1104 1955 1108 1949 1112 1943 1116 1936 1120 1930 1124 1924 1128 1917 1132 1911 1136 1904 1138 1897 1141 1890 1144 1883 1147 1876 1149 1869 1151 1862 1153 1854 1155 1847 1157 1840 1159 1833 1160 1825 1162 1818 1164 1811 1166 1803 1167 1796 1168 1789 1169 1781 1169 1774 1168 1766 1168 1759 1166 1752 1164 1745 1163 1737 1161 1730 1160 1722 1159 1715 1158 1708

1157 1700 1156 1693 1153 1686 1151 1679 1149 1672 1146 1665 1144 1658 1141 1652 1137 1645 1134 1639 1130 1632 1127 1626 1123 1620 1118 1614 1113 1609 1108 1602 1104 1596 1101 1590 1096 1583 1093 1577 1089 1572 1084 1569 1077 1572 1070 1575 1063 1578 1056 1581 1049 1583 1042 1586 1035 1589 1028 1593 1022 1597 1016 1600 1009 1604 1002 1607 996 1611 989 1616 984 1621 978 1626 973 1631 967 1636 961 1642 958 1648 962 1654 967 1658 973 1661 980 1663 987 1666 994 1668 1001 1672 1008 1677 1013 1684 1016 1691 1018 1699 1020 1706 1022 1713 1023 1721 1024 1728 1025 1736 1026 1743 1026 1750 1026 1758 1026 1765 1026 1773 1026 1780 1026 1788 1026 1795 1026 1803 1026 1810 1025 1818 1025 1825 1025 1833 1025 1840 1024 1847 1023 1855 1021 1862 1019 1869 1016 1876 1014 1882 1010 1888 1006 1894 1000 1898 994 1901 987 1903 980 1906 973 1909 966 1913 960 1917 954

Morpheus:

In Morpheus, outline data should be started with the phrase DIM 2 for 2-dimentional data (in blue). After that each specimens should be started by the OBJ phrase following the name of the specimen in quotations (in red). After that the CURVE phrase comes with quotations embedding an optional text right after it (in green). Each specimen must be finished with the phrase ENDOBJ.

DIM 2

OBJ "IMAGE=201.JPG"
CURVE ""

1785 960
1791 965
1797 969
1803 974
1807 980
1812 986
1817 992
1821 998
1825 1004
…
1776 966
1782 961
ENDOBJ

OBJ "IMAGE=202.JPG"
CURVE ""

1919 952
1925 956
…

CSV:

This format is supported by some programs (ex. Excel, SPSS) from which one can do the data analysis needed. Excel can be used as a platform for exporting the data to other applications. The first phrase is the name of the header (in pink), then the x and y label of the columns. The second line starts with the label of the row (in blue, ex. 201.JPG) and the coordinates (in red). Here is a sample of CSV format:

Specimen/Coordinates,x1,y1,x2,y2,x3,y3,x4,y4,x5,y5,x6,y6,x7,y7,x8,y8,x9,y9,x10,y10,x11,y11,x12,y12,x13,y13,x14,y14,x15,y15,x16,y16,x17,y17,x18,y18,x19,y19,x20,y20,x21,y21,x22,y22,x23,y23,x24,y24,x25,y25,x26,y26,x27,y27,x28,y28,x29,y29,x30,y30,x31,y31,x32,y32,x33,y33,x34,y34,x35,y35,x36,y36,x37,y37,x38,y38,x39,y39,x40,y40,x41,y41,x42,y42,x43,y43,x44,y44,x45,y45,x46,y46,x47,y47,x48,y48,x49,y49,x50,y50,x51,y51,x52,y52,x53,y53,x54,y54,x55,y55,x56,y56,x57,y57,x58,y58,x59,y59,x60,y60,x61,y61,x62,y62,x63,y63,x64,y64,x65,y65,x66,y66,x67,y67,x68,y68,x69,y69,x70,y70,x71,y71,x72,y72,x73,y73,x74,y74,x75,y75,x76,y76,x77,y77,x78,y78,x79,y79,x80,y80,x81,y81,x82,y82,x83,y83,x84,y84,x85,y85,x86,y86,x87,y87,x88,y88,x89,y89,x90,y90,x91,y91,x92,y92,x93,y93,x94,y94,x95,y95,x96,y96,x97,y97,x98,y98,x99,y99,x100,y100,x101,y101,x102,y102,x103,y103,x104,y104,x105,y105,x106,y106,x107,y107,x108,y108,x109,y109,x110,y110,x111,y111,x112,y112,x113,y113,x114,y114,x115,y115,x116,y116,x117,y117,x118,y118,x119,y119,x120,y120,x121,y121,x122,y122,x123,y123,x124,y124,x125,y125,x126,y126,x127,y127,x128,y128,x129,y129,x130,y130,x131,y131,x132,y132,x133,y133,x134,y134,x135,y135,x136,y136,x137,y137,x138,y138,x139,y139,x140,y140,x141,y141,x142,y142,x143,y143,x144,y144,x145,y145,x146,y146,x147,y147,x148,y148,x149,y149,x150,y150
201.JPG,1785, 960, 1791, 965, 1797, 969, 1803, 974, 1807, 980, 1812, 986, 1817, 992, 1821, 998, 1825, 1004, 1829, 1011, 1832, 1018, 1835, 1025, 1838, 1032, 1841, 1039, 1843, 1046, 1845, 1053, 1848, 1060, 1849, 1068, 1851, 1075, 1852, 1082, 1852, 1090, 1848, 1096, 1844, 1102, 1837, 1107, 1832, 1112, 1825, 1116, 1819, 1120, 1812, 1124, 1806, 1127, 1799, 1131, 1793, 1135, 1786, 1138, 1779, 1141, 1772, 1144, 1765, 1146, 1758, 1149, 1751, 1152, 1744, 1154, 1737, 1157, 1730, 1160, 1722, 1161, 1715, 1163, 1708, 1165, 1700, 1166, 1693, 1168, 1685, 1169, 1678, 1171, 1671, 1172, 1663, 1174, 1656, 1174, 1648, 1175, 1641, 1175, 1633, 1175, 1626, 1174, 1618, 1173, 1611, 1172, 1603, 1170, 1596, 1169, 1589, 1167, 1581, 1166, 1574, 1165, 1566, 1163, 1559, 1162, 1552, 1160, 1545, 1157, 1537, 1155, 1530, 1153, 1523, 1150, 1516, 1147, 1510, 1143, 1503, 1140, 1497, 1136, 1491, 1131, 1484, 1127, 1478, 1123, 1472, 1119, 1465, 1115,

1459, 1111, 1452, 1108, 1445, 1104, 1439, 1100, 1434, 1095, 1432, 1087, 1433, 1080, 1435, 1073, 1438, 1066, 1439, 1058, 1441, 1051, 1444, 1044, 1447, 1037, 1450, 1030, 1453, 1023, 1456, 1016, 1459, 1009, 1463, 1003, 1468, 997, 1472, 991, 1477, 985, 1482, 979, 1487, 973, 1492, 968, 1498, 964, 1505, 962, 1512, 966, 1516, 971, 1520, 978, 1523, 985, 1525, 992, 1527, 999, 1530, 1007, 1533, 1013, 1538, 1019, 1543, 1024, 1550, 1028, 1557, 1030, 1565, 1032, 1572, 1034, 1579, 1036, 1586, 1038, 1594, 1038, 1602, 1038, 1609, 1038, 1617, 1037, 1624, 1037, 1632, 1037, 1639, 1037, 1647, 1037, 1654, 1037, 1662, 1037, 1669, 1038, 1677, 1038, 1685, 1038, 1692, 1037, 1700, 1037, 1707, 1035, 1714, 1033, 1721, 1031, 1728, 1028, 1736, 1026, 1742, 1023, 1748, 1018, 1752, 1012, 1755, 1005, 1758, 998, 1761, 991, 1763, 984, 1766, 977, 1770, 970, 1776, 966, 1782, 961

202.JPG,1919, 952, 1925, 956, 1931, 960, 1937, 965, 1942, 970, 1947, 976, 1951, 982, 1956, 988, 1960, 994, 1965, 1000, 1969, 1006, 1973, 1013, 1976, 1020, 1979, 1026, 1982, 1033, 1986, 1040, 1989, 1047, 1992, 1053, 1994, 1061, 1996, 1068, 1995, 1075, 1991, 1082, 1986, 1086, 1980, 1091, 1974, 1096, 1968, 1100, 1962, 1104, 1955, 1108, 1949, 1112, 1943, 1116, 1936, 1120, 1930, 1124, 1924, 1128, 1917, 1132, 1911, 1136, 1904, 1138, 1897, 1141, 1890, 1144, 1883, 1147, 1876, 1149, 1869, 1151, 1862, 1153, 1854, 1155, 1847, 1157, 1840, 1159, 1833, 1160, 1825, 1162, 1818, 1164, 1811, 1166, 1803, 1167, 1796, 1168, 1789, 1169, 1781, 1169, 1774, 1168, 1766, 1168, 1759, 1166, 1752, 1164, 1745, 1163, 1737, 1161, 1730, 1160, 1722, 1159, 1715, 1158, 1708, 1157, 1700, 1156, 1693, 1153, 1686, 1151, 1679, 1149, 1672, 1146, 1665, 1144, 1658, 1141, 1652, 1137, 1645, 1134, 1639, 1130, 1632, 1127, 1626, 1123, 1620, 1118, 1614, 1113, 1609, 1108, 1602, 1104, 1596, 1101, 1590, 1096, 1583, 1093, 1577, 1089, 1572, 1084, 1569, 1077, 1572, 1070, 1575, 1063, 1578, 1056, 1581, 1049, 1583, 1042, 1586, 1035, 1589, 1028, 1593, 1022, 1597, 1016, 1600, 1009, 1604, 1002, 1607, 996, 1611, 989, 1616, 984, 1621, 978, 1626, 973, 1631, 967, 1636, 961, 1642, 958, 1648, 962, 1654, 967, 1658, 973, 1661, 980, 1663, 987, 1666, 994, 1668, 1001, 1672, 1008, 1677, 1013, 1684, 1016, 1691, 1018, 1699, 1020, 1706, 1022, 1713, 1023, 1721, 1024, 1728, 1025, 1736, 1026, 1743, 1026, 1750, 1026, 1758, 1026, 1765, 1026, 1773, 1026, 1780, 1026, 1788, 1026, 1795, 1026, 1803, 1026, 1810, 1025, 1818, 1025, 1825, 1025, 1833, 1025, 1840, 1024, 1847, 1023, 1855, 1021, 1862, 1019, 1869, 1016, 1876, 1014, 1882, 1010, 1888, 1006, 1894, 1000, 1898, 994, 1901, 987, 1903, 980, 1906, 973, 1909, 966, 1913, 960, 1917, 954

After saving the output data to a file, you can open it in excel following this instruction:
1) Open Excel, from File menu choose Open and select the desired file and click Open. This will run Text Import Wizard
2) Choose delimited option in the original data type and click Next. This will guide you to next step (step 2)
3) From delimiters group check the **comma** checkbox and then click Finish. That's all.

Section 2: Size Calculation

GMTP can calculate Centroid location, Centroid Size, Are and Perimeter of outlines at once and produce an output in CSV format.

Centroid
The centroid of every shape is the mean of all coordinates of points of that shape.

$$C_x = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$C_y = \frac{\sum_{i=1}^{n} y_i}{n}$$

Centroid Size

Centroid Size is the square root of the sum of squared distances of a set of points.

$$\text{Centroid Size} = \sqrt{\sum_{1}^{n} (x_i - x_c)^2 + (y_i - y_c)^2}$$

After the calculation, the centroid size is multiplied by the scale of the image.

Area
The area of a polygon can be calculated by the formula below:

$$Area = \left| \sum_{1}^{n+1} \frac{1}{2} (x_{i+1} - x_i)(y_{i+1} + y_i) \right|$$

GMTP calculates the area of closed and open curves. This is important in case of open curves which generate an error when computing the area. GMTP automatically corrects this by adding an extra calculation for the end and start points. After that the area is multiplied by the square value of Scale of the specimen.

Perimeter
Perimeter is the sum of Euclidean distances of consecutive points from start to the end. When calculating perimeter, GMTP asks user to whether calculate open or close curve perimeter. If the curve is an open one, the program adds the distance between end and start points to the total value.

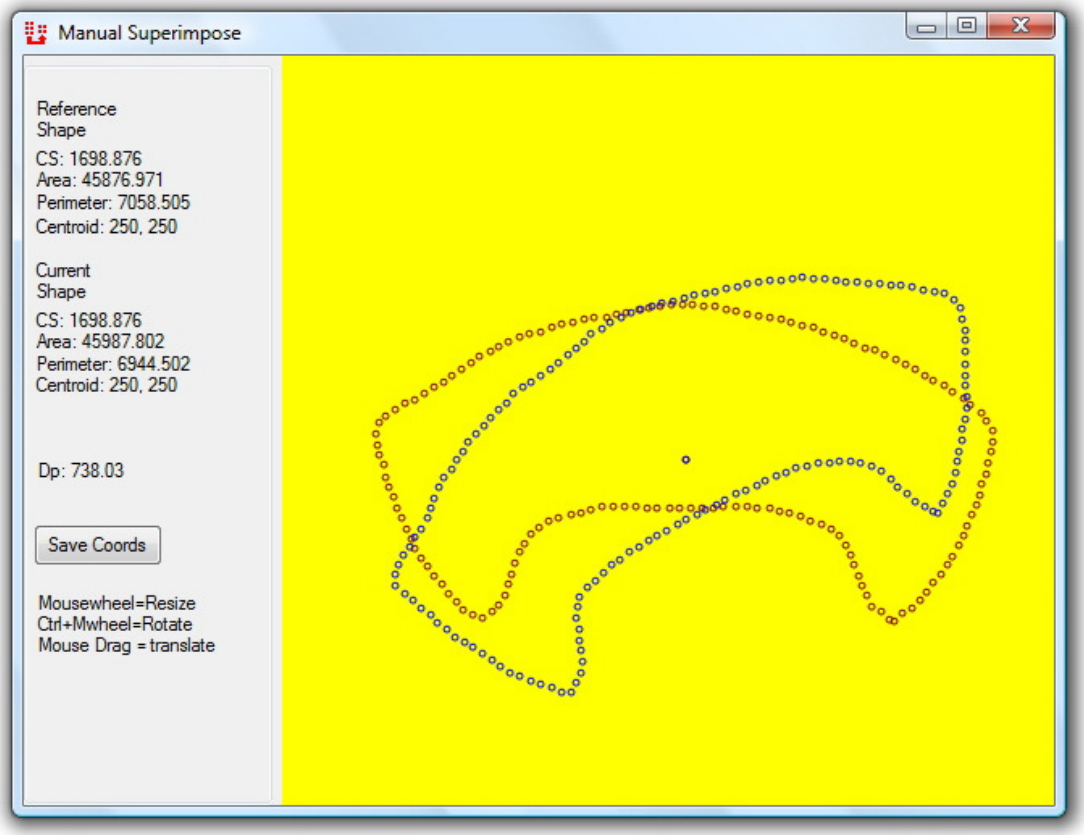
Tools

Crop by Coordinates
Idea: Prof. Jamshid Darvish
This tool crops all the images of a .tps file. Currently, GMTP requires the image files to be in the same folder of .tps file using relative address (not absolute).
It crops the image on the basis of the outline coordinates and produces a new image containing the extracted pixels.

Visualizer
This tool draws the images from the .tps file into picture boxes. For doing so, first it standardize the coordinates by aligning the polygons and make them invariant to Location, Size and Rotation. The minimum Procrustes distance method is used to align specimens.

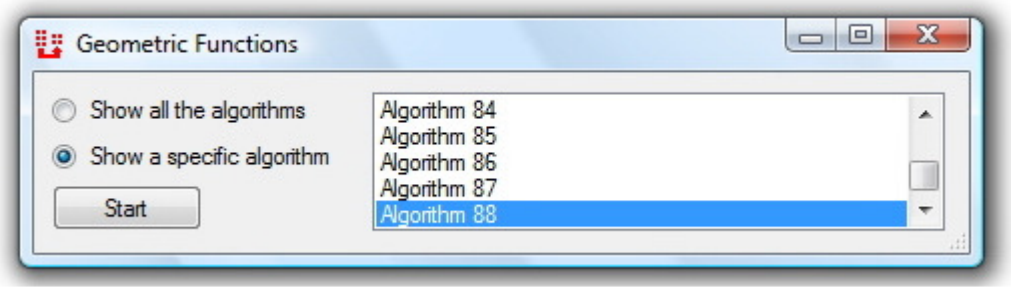
Important Note: The visualizer also produces an output containing the standardized coordinate of shapes using minimum procrustes distance. Nevertheless, this method should be chosen with caution because it is not the best method for superimposing outline shapes with dislocated starting point.

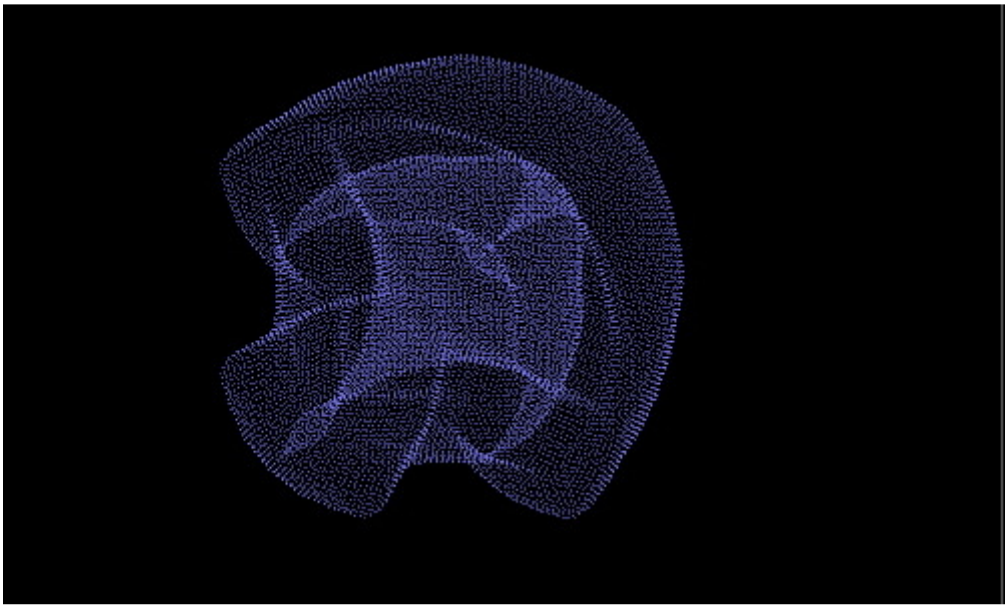
-Manual Superimpose: This feature enables users to check the effect of location, size and rotation in superimposing two shapes. This algorithm will read the first two specimen and standardize them for superimposing. Then, the user is able to rotate (ctrl+mousewheel), translate (drag and drop) and resize (mousewheel) the second shape and check how the *Dp* changes. The smaller the *Dp* the better the shapes are superimposed but this is not always tru: If the starting point of shapes are different relative to the whole shape then the *Dp* will not show the perfect superimposition. As you resize the shpe, you'll notice that size variables will change in accordance with the new shape size.



You can save the new coordinates of the two shapes in PAST format by clicking on the Save Coords button.

-Geometric Algorithms: **G**eometric algorithms are creative algorithms for drawing interesting shapes from the input shape. However, some algorithms are almost shape independent so as your desired shape changes dramatically, the resulting geometric shape will only change minutely. On the other hand, the shape dependent algorithms will change dramatically as the shape changes (i.e. when the input shape changes from a mushroom to a rodent skull). For best result, it is recommended to use shapes with 150-250 points. Shapes with number of points lower than 100 or more than 250 will result in flat or filled shape respectively. When you start Geometric Algorithms, a window will appear asking you whether you want run a specific algorithm or all the available algorithms:





A geometric shape produced by geometric algorithm from the shape of the pronotum of a beetle (*Erodiontes aelleni*).

These shapes currently have no scientific purpose but may be used for particular shape approximations.

-Options: Has many options for drawing. The first tab contains the general options for drawing which have impact on almost all the drawing. There are also two other tabs for specifying the options of Manual Superimpose and Geometric algorithms.

General Options:

Show Specimen info
Displays the info of specimens on each image

Specimen info
Contains a list of variables which GMTP reads and display on final images

Form Size
The size of the visualize form in pixel

Text
The format of the text including Color, Font, text size and font style

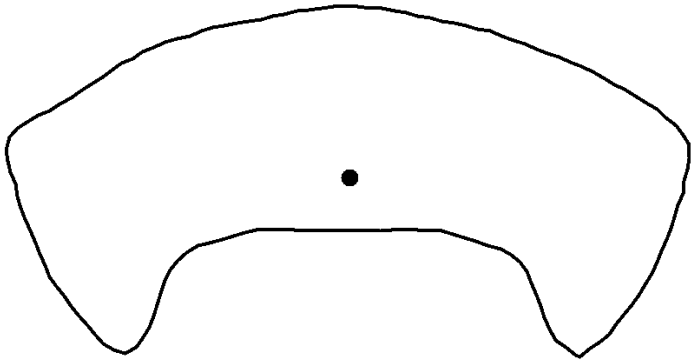
Save
Has two checkboxes for saving the results as PAST file and JPEG files.

Cell Size
The size of each cell containing the shape of specimen

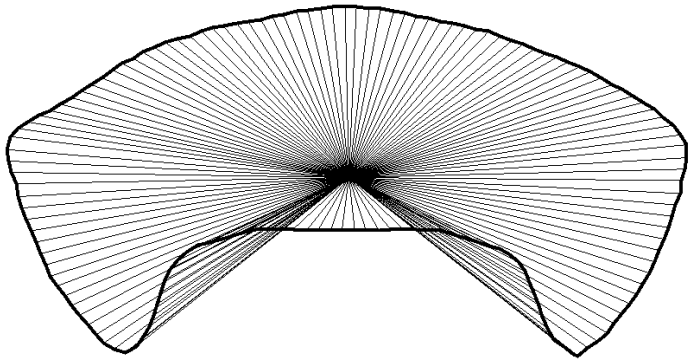
Rotation
Arbitrary rotation entered by user in degrees from -360 to +360.

Drawing
This section has many options for drawing.

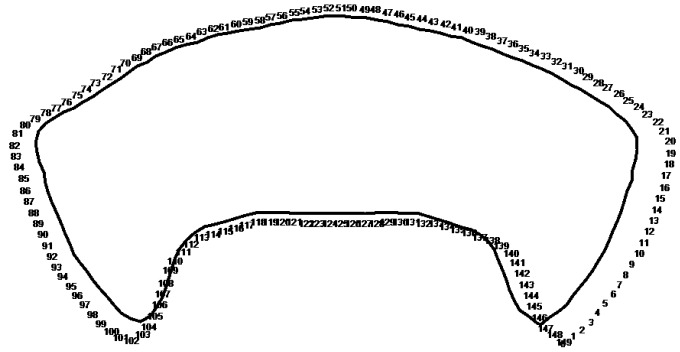
-**Show centroid**: displays centroid on the shape



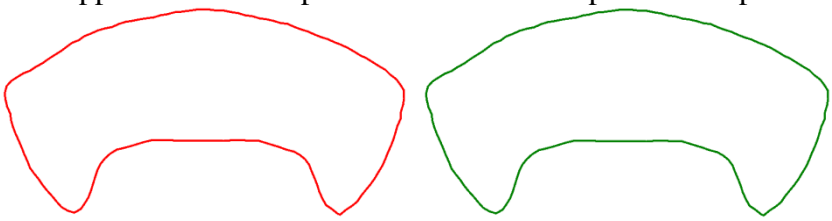
-**Show radial Lines**: displays all the lines from outline points to the centroid



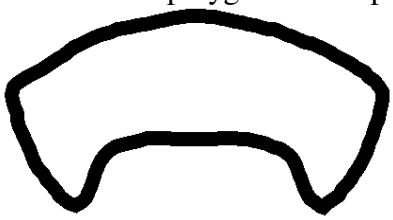
-**Show point number**: displays the index number of each point so that the points can get tracked



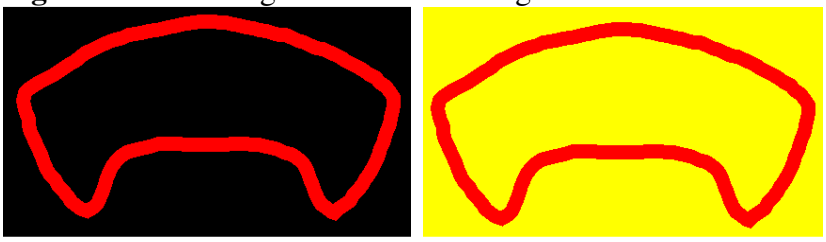
-**Color**: Color of outline (polygon or point). Dynamic option draws shapes with different colors when it encounters a different ID. This feature only works when several tps files have been appended. Fixed option draws all the shapes with a specified color.



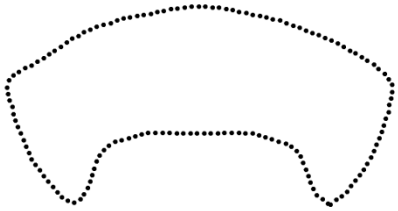
-**Line width**:
The width of polygon line or points.



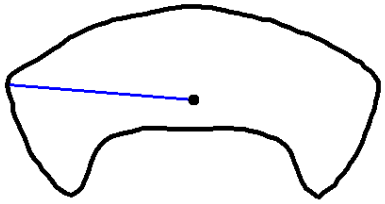
-**BgColor**: The background color of images.



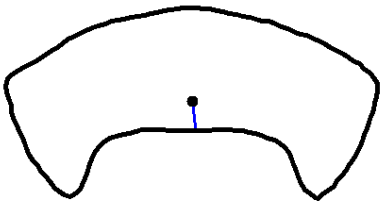
-**Shape**: Asks to whether draw polygons or only points at the digitized coordinates.



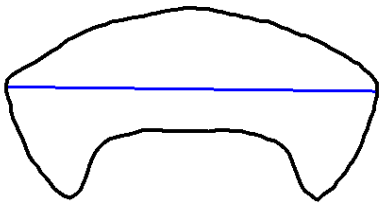
-**Sh. MaxLine**: Draws a line from the farthest point from centroid to the centroid. Notice: It will only draw one line so if there are more than one point with maximum distance from centroid, they'll be ignored.



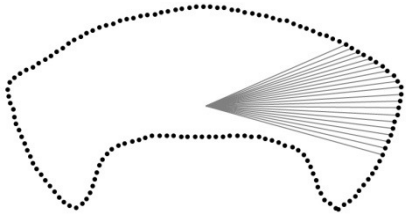
-**Sh. MinLine**: Draws a line from the nearest point on the contour to centroid. Notice: It will only draw one line so if there are more than one point with minimum distance from centroid, they'll be ignored.



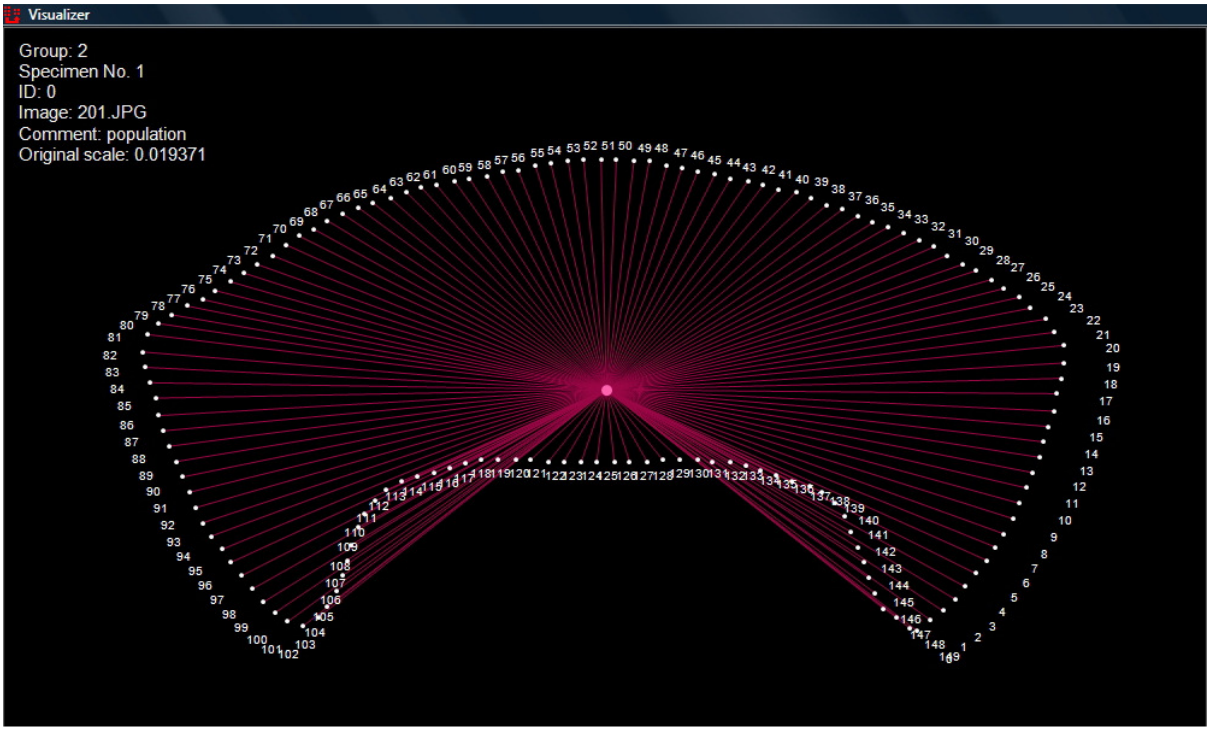
-**Sh. Widest Line**: Draws a line passing through the farthest points from each other. Notice: It will only draw one line so if there are more than one maximum line they'll be ignored.



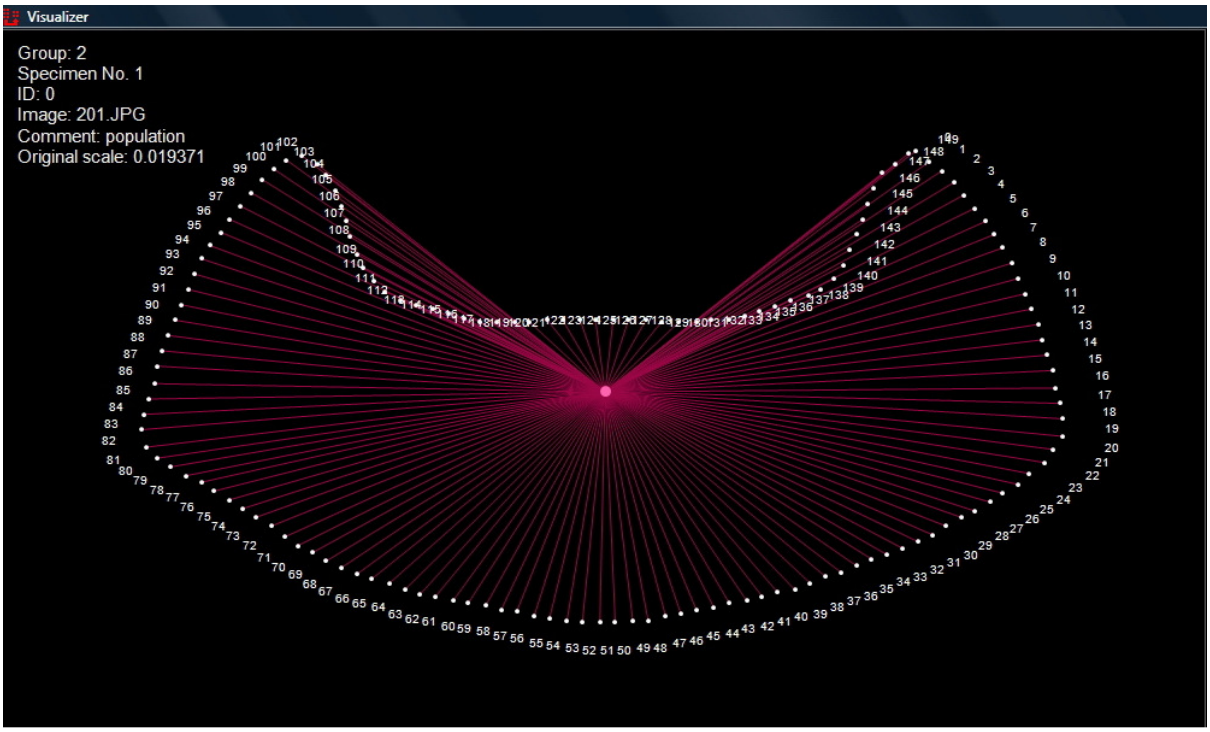
-**TrackLines**: Draws Radial lines from centroid to specific points choosed by user.



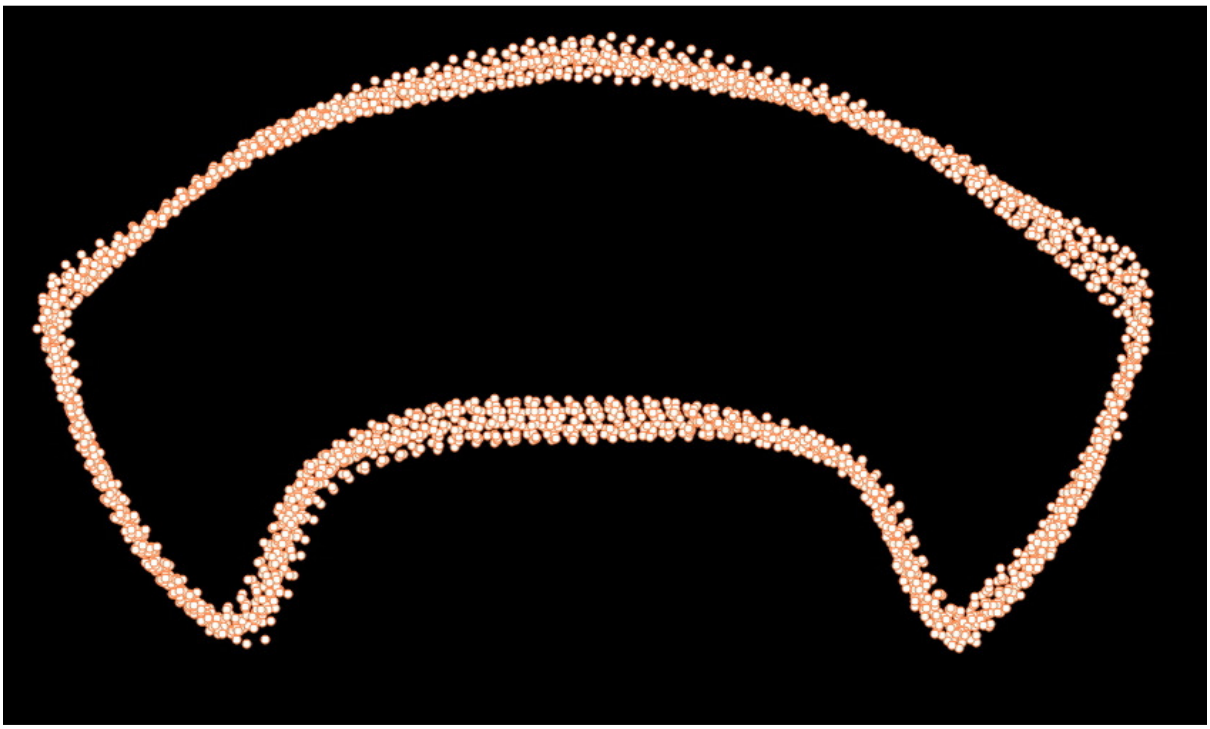
-**Convert Cartesian coordinates to computer coordinates**: Converts the shape to its mirror image. This is useful for preserving the correct orientation of shape when drawing a shape with Cartesian coordinates in computers. The left picture below has been drawn by converted Coordinates in which the starting point is the lower left process of the shape. The right picture has been drawn without conversion in which the starting point is the upper right process of the shape.
The first picture below shows the shape with converted coordinates to Cartesian coordinate system.



The below picture has drawn without Cartesian conversion. This exactly the mirror image of the upper image in reference to X(horizontal) axis. Compare the order of point numbers. Notice: tpsDig saves the coordinates in Cartesian coordinate system. Therefore if you want to preserve the original orientation of your shape, you have to use this conversion or your shape will be transformed to its mirror image.



-Superimpose: Superimposes all the specimens on each other in a single image.



-Mean shape: Computes the mean shape by averaging the standardized coordinates.