

AUTOMATED PATTERN RECOGNITION
OF BEEF

by

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I. INTRODUCTION

The price of the meat is one of the major concerns for consumers going to the supermarket. It is determined by the quality grade and yield grade, which are obtained by human judgement. There are two factors that determine the quality grade. The first one is the total area of fat inside the loin eye area, called marbling. Secondly, the maturity of the beef. The formula for calculating yield grade is:

$$YG = 2.5 + 2.5FT + 0.2\%KPH + 0.0038HCW - 0.32LEA$$

where YG = Yield Grade; an integer number.

FT = Fat Thickness in inches.

%KPH = Percent Kidney, Pelvis, and Heart fat.

HCW = Hot Carcass Weight in pounds.

LEA = Loin Eye Area in square inches.

Presently, the loin eye area, marbling area, and the fat thickness are found by using transparencies on the beef, and the scale unit is 1/10". So, there will be an error from -0.25 to +0.25 for 2.5FT and from -0.16 to +0.16 to -0.32 to +0.32 for 0.32LEA, where -0.16 to +0.16 is for 6 square inches' loin eye area, and -0.32 to +0.32 is for 25 square inches' loin eye area. The typical values for loin eye area are from 6 square inches to 25 square inches. These two errors are just the scale error. A combined error of ± 0.41 to ± 0.61 is produced in FT and LEA when using a grid resolution of 1/10". Even just the average error will still be ± 0.2 to ± 0.3 . If one adds the errors that the human grader makes, which range around 30%, and the KPH error,

which is a judgement, the total error will be still larger. Also, this kind of judgement is not fast enough to deal with the large quantity of meat and still be highly accurate. So, the idea of using a computer to take care of this judgement is forth coming.

The proposed system as shown in Fig. 1 contains a CCD camera, digitizer, memory, and microcomputer. When a piece of beef is scanned by a CCD camera, digitized and the results stored in memory, then the microcomputer will have the information about the beef available. The system permits rapid acquisition of a digital matrix representation light intensities in a scene. The size of the matrix is dependent upon the CCD camera⁽¹⁾ but may be as large as 226 X 492 points. The quantized data will be classified via thresholding into 3 categories. Each point of the matrix contains a two-bit number, "0" for background, "2" for fat, and "3" for meat. By means of certain algorithms with inputs of KPH and HCW, the computer can obtain the yield grade.

This report deals with the developments of the desired algorithms. Since the CCD camera and digitizer are currently not available, the matrix was be reduced in size to 50 X 72 points, and then using a transparency grid on a photograph, the data was quantized manually. Also, the IBM 370 was used to perform the related calculations.

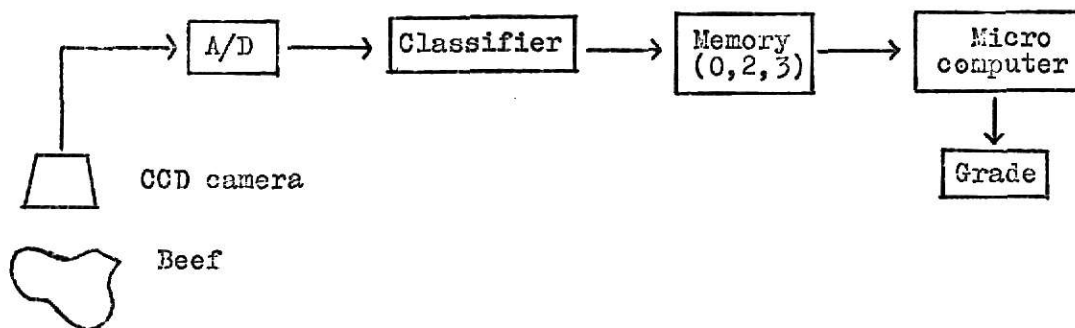


Fig. 1. Proposed beef grading system.

II. THE GRADING PROCESS

When a piece of beef is passed by the system as shown in Fig. 1, the full system will operate as the following steps:

- Step 1. The CCD camera will take the picture of beef, and divided this picture into 226 X 492 points.
- Step 2. A/D converter will digitized the level of each point according to its light intensity.
- Step 3. The classifier will identify which parts are background, fat, and meat.
- Step 4. Define the background as "0", fat as "2", and meat as "3", and store in memory.
- Step 5. A microcomputer will use the methods described in the section that follows to obtain the yield grade.

In this report the process for finding the loin eye area and fat thickness will be discussed. The cuts of meat that were used are shown in Figure 2. The points of interest are labeled in the figure as the loin eye region and fat thickness. The loin eye area is the area within the loin eye region enclosed by the

dark line. The fat thickness can be determined by the following steps.

- Step 1. Find the largest axis of the loin eye area.
- Step 2. Find the 3/4 point of this axis from bone end.
- Step 3. Find the line perpendicular to largest axis and passing through the 3/4 point of the axis.
- Step 4. Find the intersection of this line and loin eye boundary, define it as A.
- Step 5. Find the shortest distance between point A and boundary points between background and fat. This location is shown in Fig. 2 by the location of the ruler.

These 3 photograph were obtained from the Department of Animal Science & Industry. Figure 3 shows the flow diagram for overall program.

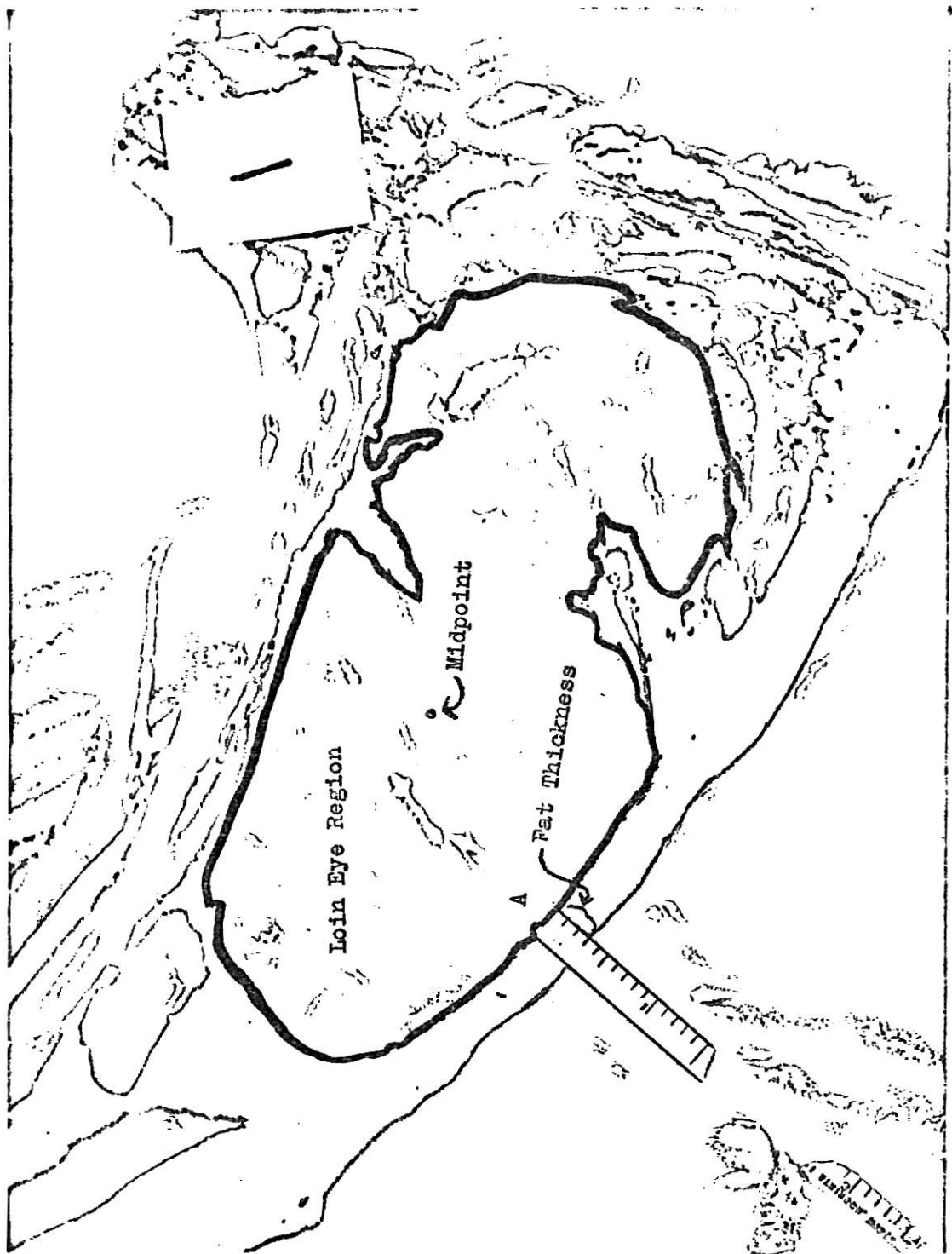


Fig. 2a. Photograph of the cut of beef.

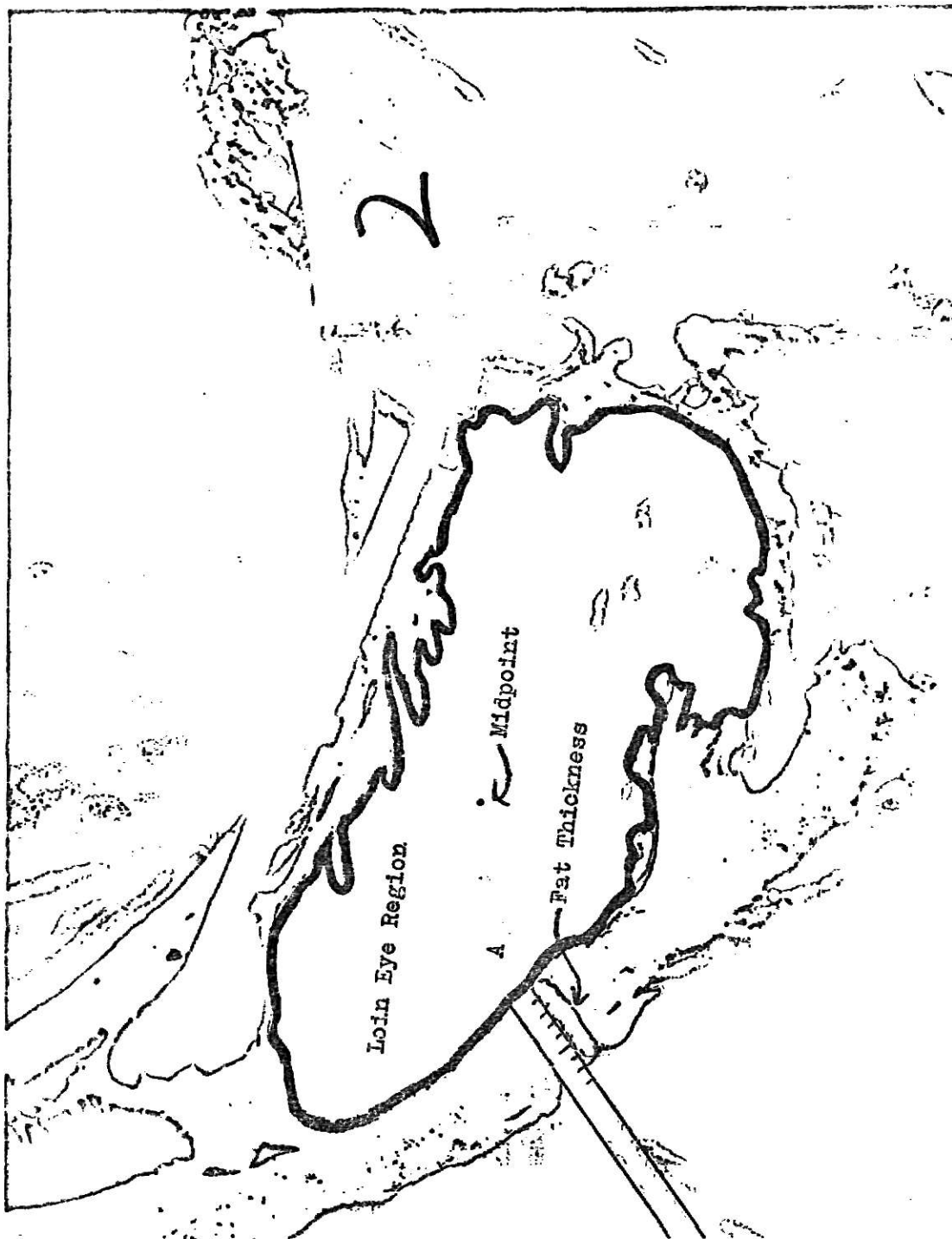


Fig. 2b. Photograph of the cut of beef.

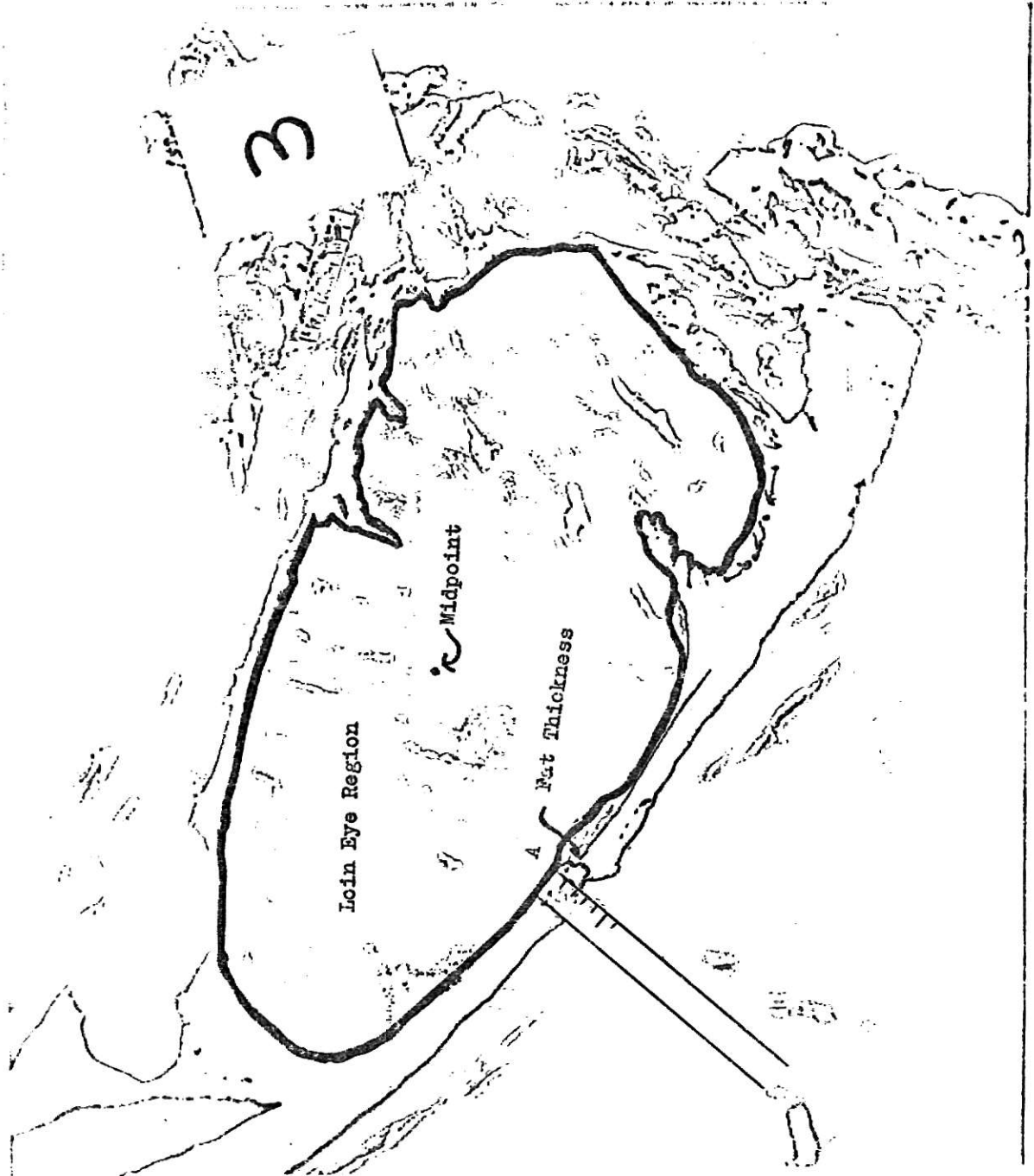


Fig. 2c. Photograph of the cut of beef.

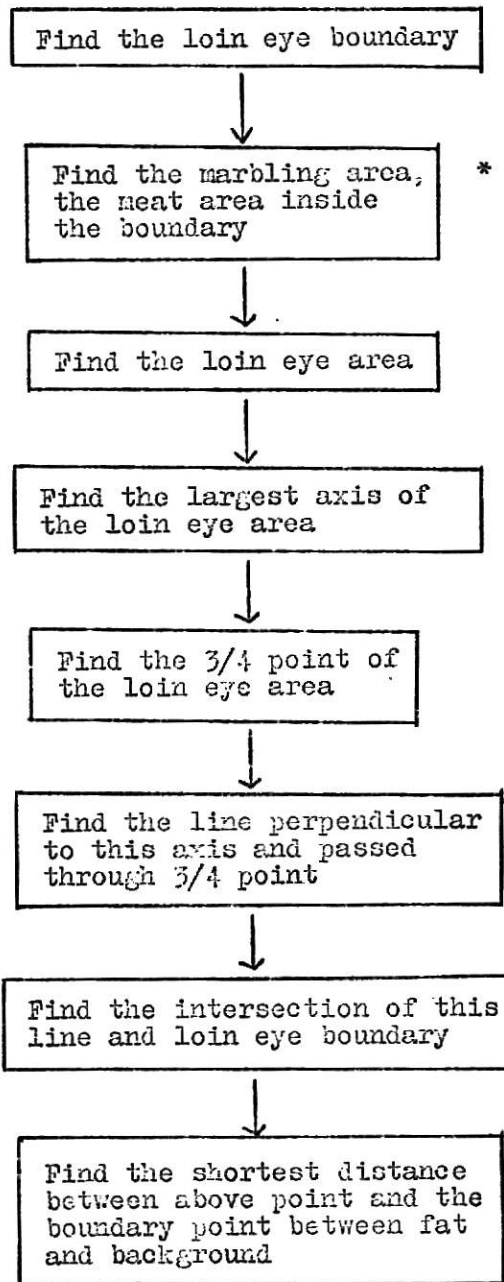


Fig. 3. Flow diagram for overall program.

* Not needed for yield grade but only for quality grade.

III. EXPLANATION OF ALGORITHM

There have been many algorithms^{c)} developed for finding the edges and areas of pictures, because of time and memory limitations they can not be applied to the problem of finding the boundary and area of the loin eye region. Therefore we have developed algorithms for this application. Before discussing these algorithms, there are some assumptions which must be made in order to detect a boundary and yet save computing time. After getting the information about the boundary and structure of the loin eye area, the following assumptions will be made.

1. The classifier can distinguish the background, fat, and meat in a given photograph.
2. In Fig. 2, if 226 X 492 points are used, the fat cells defining the boundary are at least two cells wide. In the case of hand reduced data, it is also assumed that the fat cells outside the boundary at the right side are at least two cells wide.
3. The midpoint of the photograph is inside the loin eye area.
4. The cut of meat is oriented so that the two bones are located on the right side of the image.

Figure 4 shows the quantized images of the pictures in Fig. 2. This data was obtained by digitizing by hand and following the assumptions given above.

(A) Finding The Loin Boundary

Visible "edges" in a scene are often associated with abrupt changes in average gray level. In this report, if two adjacent points have different quantization levels it is defined as a boundary. The direction that the boundary moves from a point can be detected by comparing the quantization levels of that point and the other points surrounding it. The relative orientation of the first pair of points that are the same determines the direction of the boundary that will be detected. The boundary direction is defined as shown in Fig. 5.

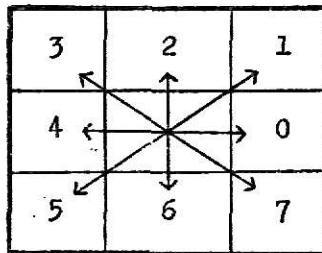


Fig. 5. Boundary direction.

The flow chart as shown in Fig. 6 is for finding the loin boundary. If the number of boundary points is less than 40, it will not be considered as the true boundary, but rather a boundary around an isolated fat area inside the loin eye. This boundary will be reset back to 2's and the algorithm will continue on searching for the loin eye boundary.

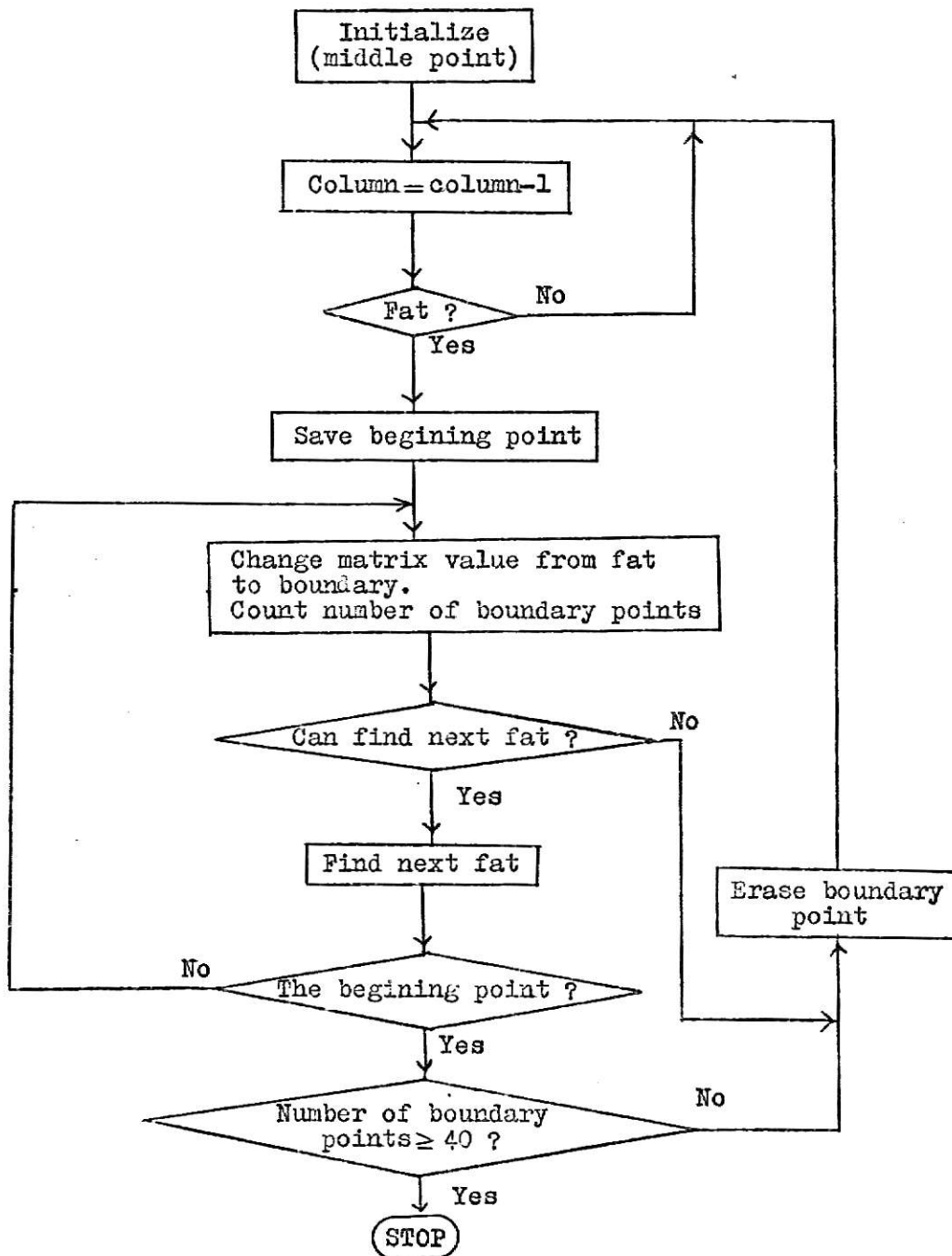


Fig. 6. Flowchart for finding the loin boundary.

The major concept for this algorithm is using the former boundary direction for a decision where it should start to find the next boundary point. Figure 7 shows the testing order for detecting a boundary point for all of the eight possible directions. In Fig. 7, the current boundary point is B, the meat cell is M, and the number from 1 to 7 indicates the testing order.

	J-1	J	J+1
I-1	5	4	3
I	6	B	2
I+1	M	M	1

(a)

	J-1	J	J+1
I-1	5	4	3
I	6	B	2
I+1	7	M	1

(b)

	J-1	J	J+1
I-1	3	2	1
I	4	B	M
I+1	5	6	M

(c)

	J-1	J	J+1
I-1	3	2	1
I	4	B	M
I+1	5	6	7

(d)

	J-1	J	J+1
I-1	1	M	M
I	2	B	6
I+1	3	4	5

(e)

	J-1	J	J+1
I-1	1	M	7
I	2	B	6
I+1	3	4	5

(f)

	J-1	J	J+1
I-1	M	6	5
I	M	B	4
I+1	1	2	3

(g)

	J-1	J	J+1
I-1	7	6	5
I	M	B	4
I+1	1	2	3

(h)

	N-4	N-3	N-2	N-1	N
M	Fat 4	M 3	M 2	M 1	

(i)

Fig. 7. The testing order for finding the boundary point.
(a) to (h); boundary directions from 0 to 7.
(i) detection of initial boundary point.

The following steps are used for finding the loin boundary.

Step 1. Starting from the midpoint of the photograph (M,N), (that means point (25,36)), find whether (M,N-1) is the first boundary point or not. If not, decrement the related column, i.e. (M,N-2), (M,N-3)...etc., until a fat point is found, and this point may be a boundary point. Now, let this point be (I,J), and assume the boundary direction was "3", because the preceding column was meat. (Fig. 7i)

After having obtained this point, only one of the following steps is carried out.

Step 2. Case I, former boundary direction was even.

If the last direction was even, then after moving to the last boundary point detected, we start searching in a direction that is one less than the previous direction. (in model 8). Therefore if the last direction was 0,2,4, or 6 we start searching in a direction of 7,1,3, or 5 respectively. (Fig. 7a,7c,7e,7g)

Case II, former boundary direction was odd.

If the last direction was odd, then after moving to the last boundary point detected, we start searching in a direction that is two less than the previous direction. (in model 8). Therefore if the last direction was 1,3,5, or 7 we start searching in a direction of 7,1,3, or 5 respectively. (Fig. 7b,7d,7f,7h)

Step 3. Starting from this initial direction, all the eight neighbors are searched in a counterclockwise direction until a fat point is detected.

Step 4. We then repeat step 2 until a closed boundary is formed.

(B) Finding The Loin Eye Area

The purpose here is to find the loin eye area and the area of marbling inside the loin eye area. This is done by scanning from the middle row to the top of the loin region and then from the middle to the bottom of the region. For each row within the loin area we scan from left to right adding up the area between boundary points. This test uses the assumption that any boundary must be more than two cells wide at the right side boundary. If the point after a boundary is fat, then that area is outside the boundary.

The following flow chart(Fig. 8) is used for finding the areas of meat and marbling inside the loin eye boundary.

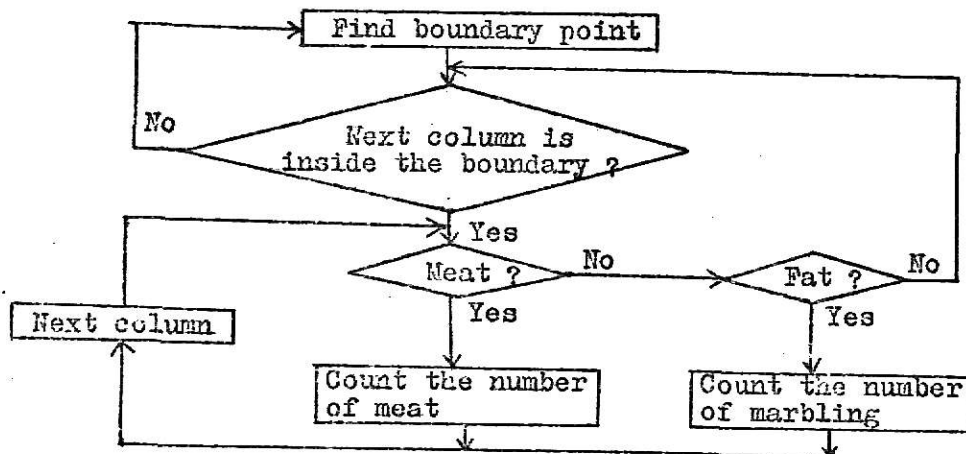


Fig. 8. Flowchart for finding the areas of marbling and meat inside the loin boundary.

In Fig. 9 a more detailed flow chart is given for finding the areas of marbling and meat inside the loin boundary. This can be broken down into the following steps.

- Step 1. Search M row from the first column to the last column to find the boundary point.
- Step 2. After the boundary point is found, the next column tested may be meat, fat, or another boundary.
- Step 3. If it is meat, count it to the meat, then go to step 6.
- Step 4. If it is fat, then go to step 1. (step 1 will start from present row, next column)
- Step 5. If it is a boundary, then go to step 2.
- Step 6. Find whether the next column is meat, fat, or boundary.
- Step 7. If it is meat, count it as meat, then go to step 6.
- Step 8. If it is fat, count it as fat, then go to step 6.
- Step 9. If it is a boundary, then go to step 2.

After finishing the M row, it will begin to test the M+1 row, M+2 row...etc., until it can not find any boundary point in a row. Then it will record this row as row IB, (the bottom row of the loin eye), and change to test the M-1 row, M-2 row...etc., until it can not find any boundary point in a row. Next it will record this row as row IA. (the top row of the loin eye). At this point the areas of marbling and meat inside the loin boundary have been completely determined. The loin eye area is the result of those two areas added together.

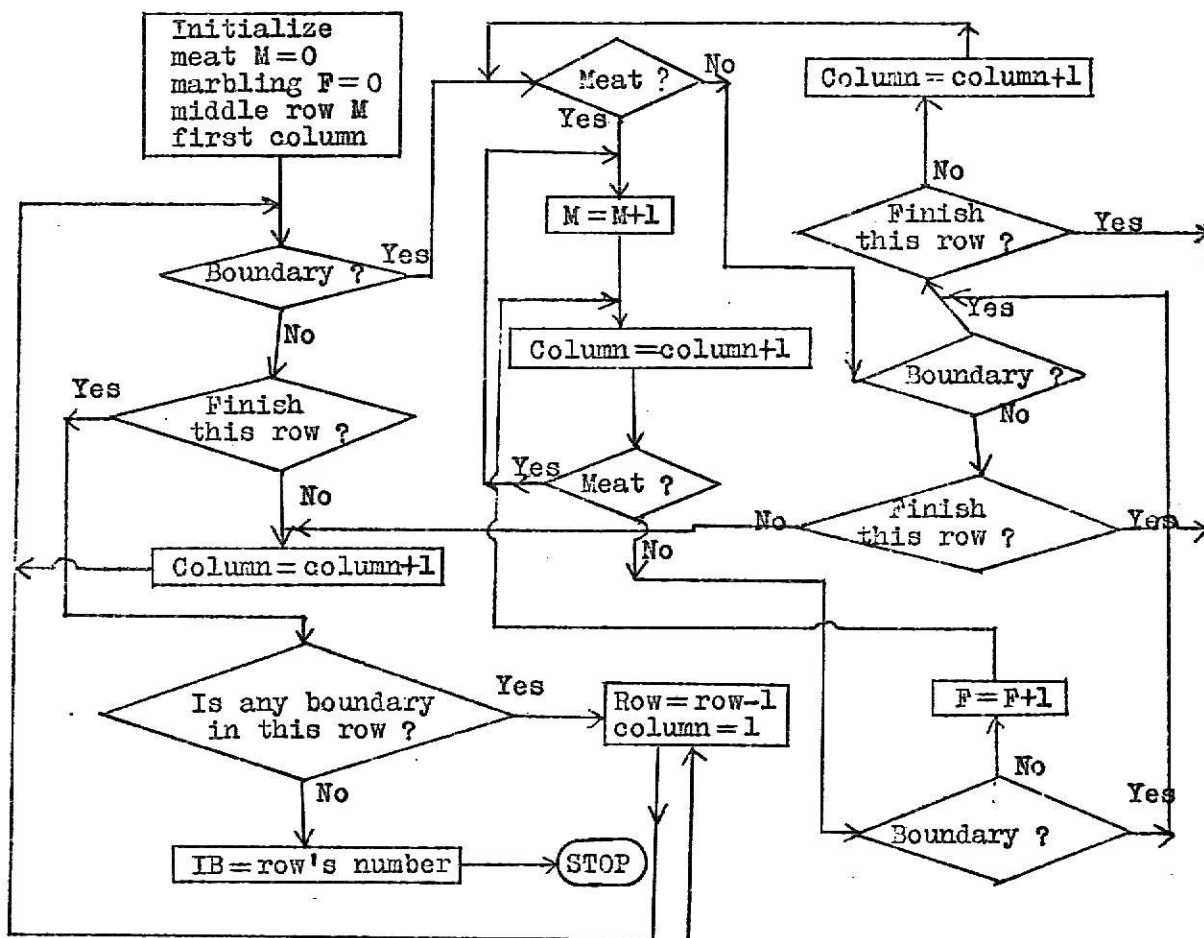


Fig. 9. The flowchart for finding the areas of marbling and meat inside the loin boundary above the M-th row.

The algorithm for finding IA and the areas below the M-th row is, of course, very similar to that given above.

(C) Finding The Fat Thickness

Fat thickness has already been defined in Section III.

The following procedure is used to find it.

(1) Find Center

So far, the top and bottom boundary rows have already been found, so it is easy to find the middle row of the loin area. Now, the left-most and right-most columns of the loin area still need to be found. After getting them, the middle column of the loin area is found. The center point of the loin eye area will be assumed to be the middle row and middle column of the loin eye area. Two methods for finding these boundary points are described. The following steps and Fig. 10 are for finding the left-most and right-most boundary columns by the first method.

- Step 1. From first column and first row, determine if it is a boundary point or not.
- Step 2. If it is not a boundary point, then test a point in the same column, and $row = row + 1$.
- Step 3. If there is no boundary point in this column, then let $column = column + 1$, $row = 1$, and go to step 2.
- Step 4. If it is a boundary point, then record this point as (IL, JL) , and go to step 5. Note IL is recorded for the next procedure.
- Step 5. From the last column, first row, determine if it is a boundary point or not.
- Step 6. If it is not a boundary point, then test a point in the same column, and $row = row - 1$.

Step 7. If there is no boundary point in this column, then let
 $\text{column} = \text{column} - 1$, $\text{row} = 1$, and go to step 6.

Step 8. If it is a boundary point, then record this column as
 JR. So, the center point of the loins eye area is
 $((\text{IA} + \text{IB})/2, (\text{JR} + \text{JL})/2)$.

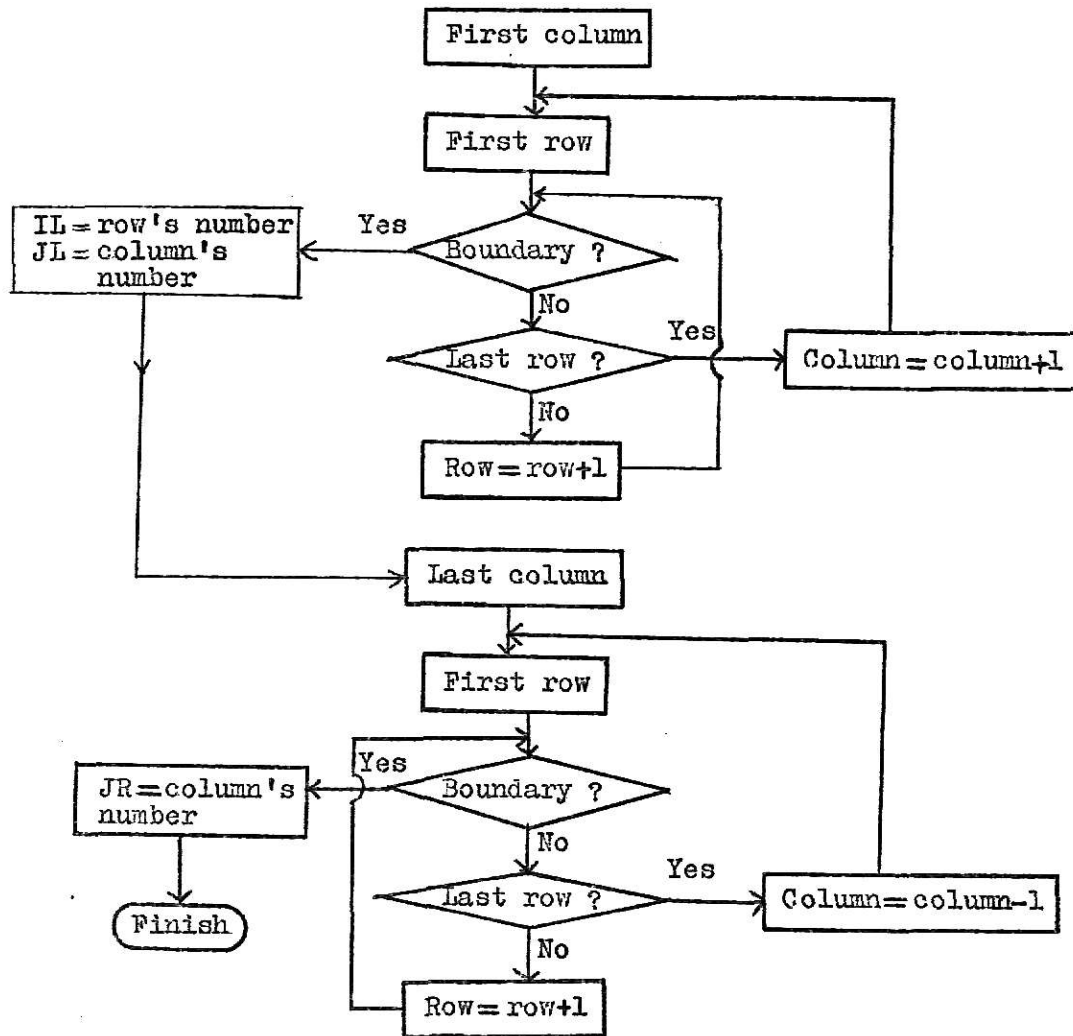


Fig. 10. Flowchart for finding left-most and right-most columns.

Another method to find the center point is during the finding of loin eye boundary. The following steps are used in this method for finding the left-most and right-most columns.

- Step 1. When the first boundary point is found, record its row and column as the left-most boundary (IL,JL), and as the right-most boundary point (IR,JR).
- Step 2. When another boundary point is found, compare its column with the current left-most boundary point (IL,JL). If it is smaller, then record this boundary point as the current left-most boundary point (IL,JL).
- Step 3. Compare its column with the current right-most boundary point (IR,JR). If it is larger, then record this boundary point as the current right-most boundary point (IR,JR).
- Step 4. After finding the boundary, the center point of the loin eye area can be found using the results of step 2 and 3. Note, the largest column will be called JR, the smallest column will be called JL.

(2) Find Maximum Distance and $3/4$ Perpendicular Line's Equation

From Fig. 2, it is easy to see that the largest axis of the loin eye area is very close to the line passing through the left-most point (IL,JL) and the center point (IM,JM) obtained previously. There are two methods for finding the maximum distance. The flowchart for the first method for finding the maximum distance is shown in Fig. 11. This method finds the maximum distance between the midpoint and several boundary points near the left-most boundary point.

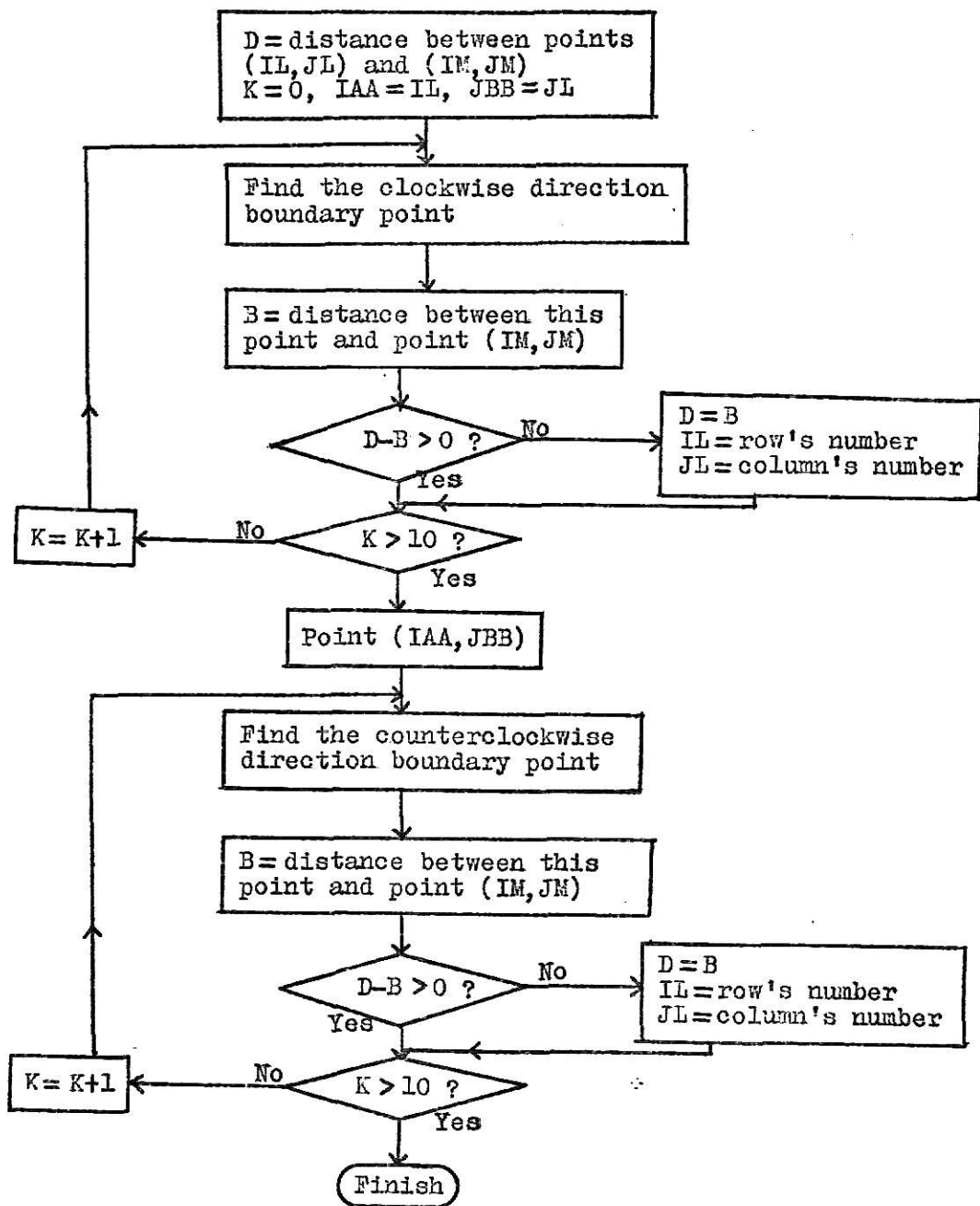


Fig. 11. The flowchart for finding the maximum distance.

The following steps can be used to find the largest axis of the loin eye area, the 3/4 point of this axis, and equation of the line passing through this point by using the first method.

- Step 1. Find the distance between points (IL,JL) and (IM,JM), let it be D.
- Step 2. Find the next clockwise direction boundary point from point (IL,JL).
- Step 3. Find the distance between this point and point (IM,JM).
- Step 4. Use this method to find 5 continuous boundary points, and calculate their distances to the point (IM,JM).
- Step 5. Find the next counterclockwise direction point to the point (IL,JL).
- Step 6. Find the distance between this point and point (IM,JM).
- Step 7. Use this method to find 5 continuous boundary points and calculate their distances to the point (IM,JM).
- Step 8. Compare these 10 different distances with D, and find the maximum one.
- Step 9. Record the point which is the maximum distance to point (IM,JM) as (IL,JL).
- Step 10. Find the largest axis' slope. This value will be $(IM-IL)/(JM-JL)$.
- Step 11. Find its perpendicular line's slope. This value will be $-(JM-JL)/(IM-IL)$.
- Step 12. Find the 3/4 point of the largest axis of the loin eye area, let it be (ID,JD), where $ID=(IM-IL)/2$ and $JD=(JM-JL)/2$.

Step 13. Use the values obtained from step 12 and the slope obtained from step 11 to find the equation for the perpendicular bisector. Using $y = mx + b$, where y = row's number, x = column's number. Now, m , the slope and the point (ID, JD) are already known. Thus it is easy to find b .

The second method for finding the maximum distance is more accurate than the above method, since it does not assume this line goes through the midpoint. This method finds the maximum distance between the left-most point (IL, JL) and several boundary points in the right side. This algorithm is as follows:

- Step 1. Use the method mentioned above, from step 1 to step 9.
- Step 2. From point (IM, JM) , test its next column point $(IM, JM+1)$, $(IM, JM+2)$, ...etc., until find the boundary point. Suppose this point is (IR, JR) , then find the distance between point (IL, JL) and point (IR, JR) , let it be D .
- Step 3. Find the next clockwise direction boundary point from point (IR, JR) .
- Step 4. Find the distance between this point and point (IL, JL) .
- Step 5. Use this method to find 10 continuous boundary points and calculate their distances to the point (IL, JL) .
- Step 6. Find the next counterclockwise direction boundary point from point (IR, JR) .
- Step 7. Find the distance between this point and point (IL, JL) .
- Step 8. Use this method to find 4 continuous boundary points and calculate their distances to the point (IL, JL) .

- Step 9. Compare these 14 different distances with D, and find the maximum one.
- Step 10. Record the point which is the maximum distance to point (IL, JL) as (IR, JR).
- Step 11. Find the largest axis' slope. This value will be $(IR-IL)/(JR-JL)$.
- Step 12. Find its perpendicular line's slope. This value will be $-(JR-JL)/(IR-IL)$.
- Step 13. Find the 3/4 point of the largest axis of the loin eye area, let it be (ID, JD), where $ID = 1/4 \times (IR-IL) + IL$ and $JD = 1/4 \times (JR-JL) + JL$.
- Step 14. Use this point and step 12's slope to find the perpendicular line's equation. The method is the same as first method's step 13.

(3) Find Boundary Intersection

This algorithm finds the intersection point between loin boundary and perpendicular line's equation. The following steps are used for finding this intersection point.

- Step 1. Find the next boundary point in counterclockwise direction from point (IL, JL).
- Step 2. Is this point an approximate solution to the line equation?
- Step 3. If not, find next counterclockwise direction boundary point, then go to step 2.
- Step 4. If it is, then this point is the intersection between loin boundary and perpendicular line's equation.

(4) Find Fat Intersection

Define the intersection in last section as A. Then using this point the boundary point between background and fat can be found. Using this point's row as a starting point, find an edge between fat and background in this row, then calculate the distance from this edge to point A. Moving counterclockwise along the background and fat edge, calculate a new distance until the edge point is an approximate solution to the line equation. Comparing these distances and find the shortest one. This shortest one is the fat thickness. The following steps are used for finding the fat intersection and thickness.

Step 1. Find the boundary point between background and fat in the row of point A.

Step 2. Calculate the distance between this point and point A and save it.

Step 3. Is this point an approximate solution to the line equation ?

Step 4. If not, find next counterclockwise direction boundary point then go to step 2.

Step 5. If it is, find the shortest one in step 2's results.

This distance is the fat thickness.

The following flowchart (Fig. 12) is used for finding the fat thickness.

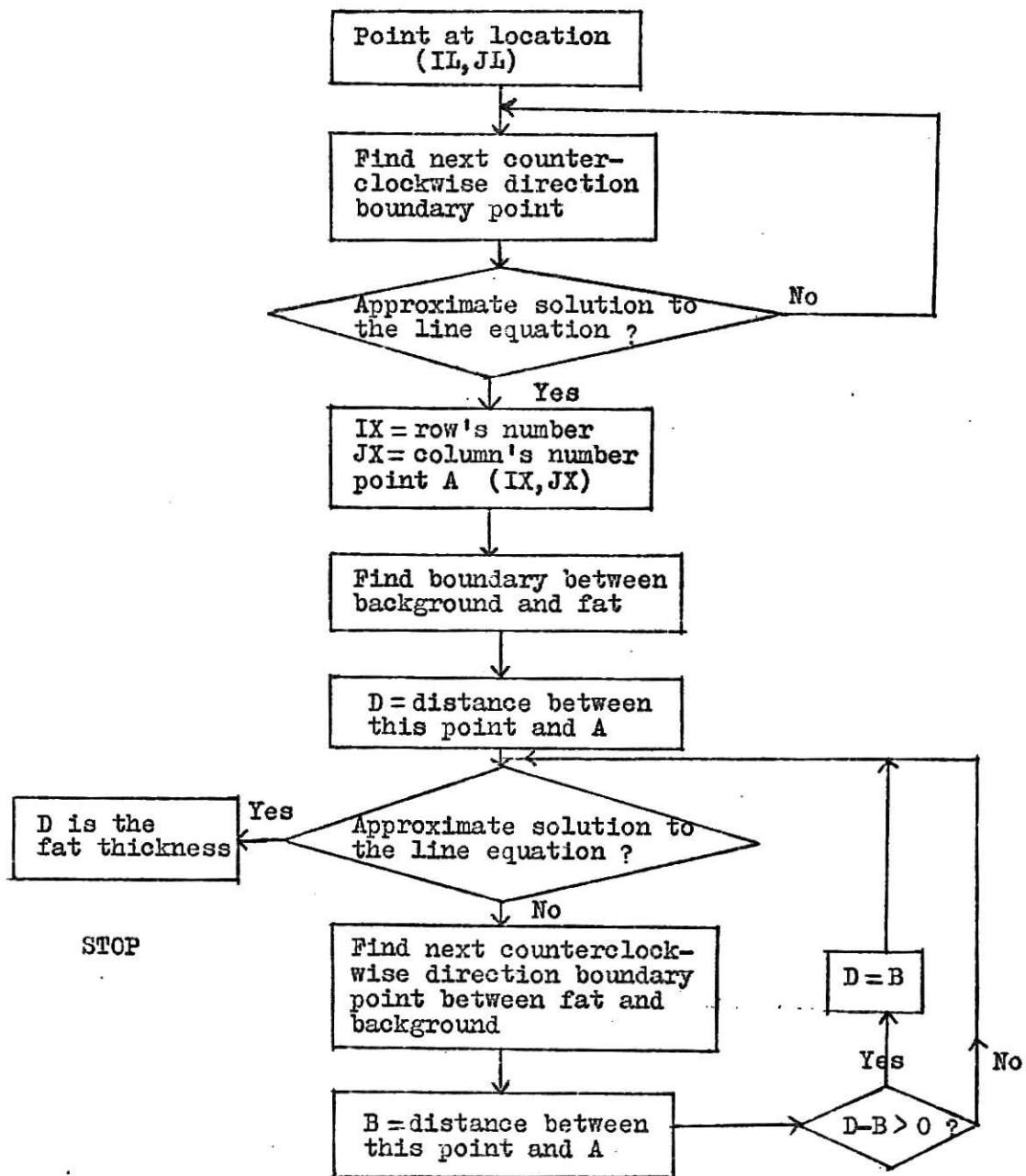


Fig. 12. The flowchart for finding the fat thickness.

IV. RESULTS OF CALCULATIONS

Using the algorithms mentioned above, for Fig. 2a, the loin eye area (LEA) was calculated to be 13.86 square inches, fat thickness (FT) was 0.303 inches and the yield grade (YG) was 2. For Fig. 2b, the LEA was calculated to be 11.59 square inches, FT was 0.707 inches and the YG was 4. For Fig. 2c, the LEA was calculated to be 15.41 square inches, FT was 0.223 inches and the YG was 1. Figure 13 shows the final output obtained by processing the data in Fig. 2 using the algorithms mentioned above. Ones indicate the boundary.

The estimates obtained via human processing for Fig. 2a, LEA=14.1 square inches, FT=0.3 inches, hot carcass weight (HCW)=838 lbs, the %KPH=2.5, and the YG=2. For Fig. 2b: LEA=11.6 square inches, FT=0.7 inches, HCW=887 lbs, the %KPH=3, and YG=4. For Fig. 2c: LEA=11 square inches, FT=0.22 inches, HCW=817 lbs, the %KPH=3, and the YG=3.

Comparing these results, for Fig. 2a and 2b, it is seen that the YG, FT, and LEA are almost the same. But for Fig. 2c, the results of the LEA and YG are quite different. After examining the photograph with Department of Animal Science & Industry, it was found that no record of the same cut of beef was available. The data for Fig. 2c that they do have is pertineet to another photograph.

ONE IS THE BOUNDARY BETWEEN FAT AND MEAT

[illegible]

Fig. 13a. The outcome of Fig. 2a by using the algorithms mentioned in this report.

[illegible]

Fig. 13b. The outcome of Fig. 2b by using the algorithms mentioned in this report.

[illegible]

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V. CONCLUSION

The algorithms presented in this paper enable one to readily compute the loin eye area, fat thickness, and with the input of other factors, to obtain the yield grade by using the microcomputer. The estimated time required for whole system by using MC 6800 microcomputer is about 7 seconds for real meat. Transferring the data from photograph to memory will take about 0.5 seconds, finding the boundary of loin eye area will take about 1.7 seconds, finding left and right most columns will take about 0.3 seconds, finding loin eye area will take about 3 seconds, finding the largest axis of the loin area and its perpendicular line's equation will take about 1.2 seconds, and finding the fat thickness will take about 0.2 seconds.

If the system uses a CCD camera with 226 X 492 cells, the scale unit will be approximately $1/32"$. Then, the maximum error will from -0.078 to +0.078 for 2.5FT and from -0.048 to +0.048 to -0.1 to -0.1 for 0.32LEA, where -0.048 to +0.048 is for a 6 square inches LEA and -0.1 to +0.1 is for a 25 square inches LEA. The typical values for loin eye areas are from 6 square to 25 square inches.

Comparing this system and human judgement, one can find that this system is as good as human judgement for isolated cut of beef, and it is better than human judgement on line production.

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APPENDIX

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FORTRAN IV G LEVEL 21          MAIN          DATE = 78133          13.
0001      REAL B,D
0002      INTEGER A
0003      DIMENSION A(60,80)
0004      C READ THE DATA FROM PICTURE
0005      READ(5,277)((A(I,J),J=1,72),I=1,50)
0006      277 FORMAT(72I1)
0007      WRITE(6,7864)((A(I,J),J=1,72),I=1,50)
0008      7864 FORMAT(5X,72I1)
0009      C MNI AND NMJ ARE USED TO FIND THE CENTER PCINT CF MASS BELONGS
0010      C TO THE LOIN EYE AREA
0011      MNI=0
0012      NMJ=0
0013      IIK=1
0014      C MIDDLE POINT OF THE PICTURE
0015      C I IS THE ROW OF THE PICTURE
0016      I=25
0017      C J IS THE COLUMN OF THE PICTURE
0018      J=36
0019      IJ=0
0020      3 J=J-1
0021      C*****
0022      C FIND THE LOIN EYE BOUNDARY, RIGHT MOST AND LEFT MOST COLUMNS
0023      C*****
0024      C FIND THE FIRST BOUNDARY PCINT
0025      IF((A(I,J)-3))5,3,5
0026      C THE FIRST BOUNDARY POINT
0027      C M IS THE MIDDLE ROW OF THE PICTURE
0028      5 M=I
0029      C N IS THE MIDDLE COLUMN OF THE PICTURE
0030      N=J
0031      C MIJ IS THE LEFT MOST COLUMN OF BOUNDARY
0032      MIJ=J
0033      C MAJ IS THE RIGHT MOST COLUMN CF BOUNDARY
0034      MAJ=J
0035      C K IS THE TOTAL BOUNDARY PCINTS
0036      K=0
0037      A(I,J)=1
0038      GO TO 18
0039      7 IF(J-MIJ)1,1,2
0040      1 MIJ=J
0041      GO TO 9996
0042      2 IF(J-MAJ)8,8,909
0043      909 MAJ=J
0044      8 GO TO 9996
0045      9996 A(I,J)=1
0046      IF((M-I))18,61,18
0047      IF((N-J))18,62,18
0048      C 61 FIND THE OTHER BOUNDARY PCINTS
0049      18 K=K+1
0050      I=I-1
0051      J=J+1
0052      GO TO 118
0053      C THE LOIN EYE BOUNDARY ?
0054      62 IF((K-40))63,63,64
0055      C NOT THE LOIN EYE BOUNDARY, RESET THE BOUNDARY PCINT
0056      63 A(I,J)=2
0057      I=I-1
0058      J=J+1

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0040      IF((A(I,J)-1))72,63,72
0041      72 J=J-1
0042      IF((A(I,J)-1))82,63,82
0043      82 J=J-1
0044      IF((A(I,J)-1))83,63,83
0045      83 I=I+1
0046      IF((A(I,J)-1))92,63,92
0047      92 I=I+1
0048      IF((A(I,J)-1))93,63,93
0049      93 J=J+1
0050      IF((A(I,J)-1))94,63,94
0051      94 J=J+1
0052      IF((A(I,J)-1))95,63,95
0053      95 I=I-1
0054      IF((A(I,J)-1))96,63,96
0055      96 I=M
0056      J=N
0057      77 J=J+1
0058      IF((A(I,J)-1))84,85,84
0059      84 I=I+1
0060      IF((A(I,J)-1))86,85,86
0061      86 J=J-1
0062      IF((A(I,J)-1))87,85,87
0063      87 J=J-1
0064      IF((A(I,J)-1))88,85,88
0065      88 I=I-1
0066      IF((A(I,J)-1))89,85,89
0067      89 I=I-1
0068      IF((A(I,J)-1))51,85,51
0069      51 J=J+1
0070      IF((A(I,J)-1))52,85,52
0071      52 J=J+1
0072      IF((A(I,J)-1))53,85,53
0073      53 I=M
0074      GO TO 3
0075      85 A(I,J)=2
0076      GO TO 77
0077      118 IF((A(I,J)-3))9,10,9
0078      9 IF(J-MIJ)73,73,74
0079      73 MIJ=J
0080      GO TO 9990
0081      74 IF(J-MAJ)75,75,76
0082      76 MAJ=J
0083      75 GO TO 9990
0084      9990 A(I,J)=1
C      FINISH THE FINDING OF BOUNDARY POINT ?
0085      IF((M-I))70,71,70
0086      71 IF((N-J))70,62,70
0087      70 K=K+1
0088      I=I+1
0089      J=J+1
0090      IF((A(I,J)-3))11,12,11
0091      12 I=I-1
0092      IF((A(I,J)-3))9,14,9
0093      14 I=I-1
0094      GO TO 118
0095      11 IF(J-MIJ)15,15,16
0096      15 MIJ=J

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0097      GO TO 9991
0098      16  IF(J-MAJ)17,17,908
0099      908 MAJ=J
0100      17  GO TO 9991
C        FINISH THE FINDING OF BOUNDARY POINT ?
0101      9991 A(I,J)=1
0102          IF((M-I))80,81,80
0103      81  IF((N-J))80,62,80
0104      80  K=K+1
0105          I=I+1
0106          J=J-1
0107          IF((A(I,J)-3))19,20,19
0108      19  IF(J-MIJ)21,21,23
0109      21  MIJ=J
0110          GO TO 9992
0111      23  IF(J-MAJ)25,25,26
0112      26  MAJ=J
0113      25  GO TO 9992
0114      9992 A(I,J)=1
C        FINISH THE FINDING OF BOUNDARY POINT ?
0115          IF((M-I))90,91,90
0116      91  IF((N-J))90,62,90
0117      90  K=K+1
0118          I=I-1
0119          J=J-1
0120          IF((A(I,J)-3))7,22,7
0121      22  I=I+1
0122          IF((A(I,J)-3))38,24,38
0123      24  I=I+1
0124          IF((A(I,J)-3))19,42,19
0125      20  J=J+1
0126          IF((A(I,J)-3))11,28,11
0127      28  J=J+1
0128          IF((A(I,J)-3))11,30,11
0129      30  I=I-1
0130          IF((A(I,J)-3))9,14,9
0131      10  J=J-1
0132          IF((A(I,J)-3))7,34,7
0133      34  J=J-1
0134      35  IF((A(I,J)-3))7,37,7
0135      37  I=I+1
0136          IF((A(I,J)-3))38,39,38
0137      38  IF(J-MIJ)27,27,29
0138      27  MIJ=J
0139          GO TO 9993
0140      29  IF(J-MAJ)31,31,32
0141      32  MAJ=J
0142      31  GO TO 9993
0143      9993 A(I,J)=1
C        FINISH THE FINDING OF BOUNDARY POINT ?
0144          IF((M-I))100,101,100
0145      101 IF((N-J))100,62,100
0146      100 K=K+1
0147          I=I-1
0148          J=J-1
0149          GO TO 35
0150      39  I=I+1
0151      40  IF((A(I,J)-3))19,42,19

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0152      42 J=J+1
0153      IF((A(I,J)-3))43,44,43
0154      43 IF(J-MIJ)33,33,36
0155      33 MIJ=J
0156      GO TO 9994
0157      36 IF(J-MAJ)54,54,55
0158      55 MAJ=J
0159      54 GO TO 9994
0160      9994 A(I,J)=1
C          FINISH THE FINDING OF BOUNDARY POINT ?
0161      IF((M-1))110,111,110
0162      111 IF((N-J))110,62,110
0163      110 K=K+1
0164      I=I+1
0165      J=J-1
0166      GO TO 40
0167      44 J=J+1
0168      IF((A(I,J)-3))43,46,43
0169      46 I=I-1
0170      IF((A(I,J)-3))9,48,9
0171      48 IF((K-1))14,49,14
0172      49 J=J-1
0173      A(I,J)=2
0174      GO TO 3
0175      64 WRITE(6,1950)
0176      1950 FORMAT('1',3X,'ONE IS THE BOUNDARY BETWEEN FAT AND MEAT')
0177      1951 WRITE(6,201)((A(I,J),J=1,72),I=1,50)
0178      201 FORMAT(5X,72I1)
C*****
C          FINISH THE FINDING OF BOUNDARY POINT
C*****
0179      I=1
0180      J=MIJ
C
C          FIND THE LEFT MOST POINT OF LOIN EYE BOUNDARY
C
0181      899 IF((A(I,J)-1))801,802,801
0182      801 I=I+1
0183      GO TO 899
C          (IL,JL) IS THE LEFT MOST POINT OF LOIN EYE BOUNDARY
0184      802 JL=J
0185      IL=I
0186      WRITE(6,1952)IL,JL
0187      1952 FORMAT(///,3X,'THE LEFT MOST POINT AT IL=',I2,3X,'JL=',I2)
0188      JR=MAJ
0189      WRITE(6,1900)JR
0190      1900 FORMAT(///,3X,'THE RIGHT MOST COLUMN JR=',I2)
C          L IS THE TOTAL MEAT CELLS INSIDE THE LOIN EYE AREA
0191      L=0
C          LL IS THE TOTAL CELLS OF MARBLING
0192      LL=0
C          LLL IS THE TOTAL BOUNDARY PCINT IN SOME ROW
0193      LLL=1
0194      I=M
0195      J=1
C*****
C          FIND THE MARBLING AREA AND LOIN EYE AREA
C*****

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0196      500 IF((A(I,J)-1))200,221,200
0197      200 J=J+1
0198          IF((J-72))300,300,400
0199      300 LLL=LLL+1
0200          GO TO 500
0201      400 IF((LLL-72))800,600,600
0202      600 LLL=1
0203          IB=I
0204          GO TO 262
0205      800 LLL=1
0206          I=I+1
0207          J=1
0208          GO TO 500
0209      221 J=J+1
0210          IF((J-72))700,700,800
0211      700 IF((A(I,J)-2))180,200,900
0212      900 L=L+1
0213          MNI=MNI+I
0214          NMJ=NMJ+J
0215      160 J=J+1
0216          IF((J-72))120,120,800
0217      120 IF((A(I,J)-2))221,150,900
0218      150 LL=LL+1
0219          MNI=MNI+I
0220          NMJ=NMJ+J
0221          GO TO 160
0222      180 IF((A(I,J)-1))200,221,200
0223      262 I=M-1
0224          J=1
0225      350 IF((A(I,J)-1))320,310,320
0226      320 J=J+1
0227          IF((J-72))330,330,340
0228      330 LLL=LLL+1
0229          GO TO 350
0230      340 IF((LLL-72))380,360,360
0231      380 LLL=1
0232          I=I-1
0233          J=1
0234          GO TO 350
0235      310 J=J+1
0236          IF((J-72))370,370,380
0237      370 IF((A(I,J)-2))480,320,390
0238      390 L=L+1
0239          MNI=MNI+I
0240          NMJ=NMJ+J
0241      460 J=J+1
0242          IF((J-72))420,420,380
0243      420 IF((A(I,J)-2))310,450,390
0244      450 LL=LL+1
0245          MNI=MNI+I
0246          NMJ=NMJ+J
0247          GO TO 460
0248      480 IF((A(I,J)-1))320,310,320
0249      360 IA=I
0250          WRITE(6,361)LL
0251      361 FORMAT(///,3X,'THE TOTAL CELLS FOR MEAT ARE',I5)
0252          WRITE(6,1979)LL
0253      1979 FORMAT(///,3X,'THE TOTAL FAT ARE',I5)

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FORTRAN IV G LEVEL 21                                MAIN                                DATE = 78133                                13
C      XL IS THE LCIN EYE AREA
0254      XL=L+LL
0255      WRITE(6,3678)XL
0256      3678 FORMAT(///,3X,'THE LOIN EYE AREA IS',F12.6)
C*****
C      FINISH THE FINDING OF MARBLING AREA AND LCIN EYE AREA
C*****
C      (XXI,XXJ) IS THE CENTER PCINT OF MASS BELNGS TO LOIN EYE ARE
0257      XXI=MNI/(L+LL)
0258      XXJ=NMJ/(L+LL)
0259      WRITE(6,4010)XXI,XXJ
0260      4010 FORMAT(///,3X,'THE CENTER ROW=',F8.4,3X,'COLUMN=',F8.4)
0261      WRITE(6,1949) IA,IB
0262      1949 FORMAT(///,3X,'UP ROW IS',I5,4X,'BOTTOM ROW IS',I5)
C*****
C      FIND THE 3/4 POINT OF LARGEST AXIS OF THE LCIN EYE AREA BY
C      USING THE FIRST METHOD
C*****
C      (IM,JM) IS THE 3/4 PCINT OF LARGEST AXIS OF THE LCIN EYE AREA
0263      IM=(IA+IB)/2
0264      JM=(JR+JL)/2
0265      W=(JM-JL)*(JM-JL)
0266      WW=(IM-IL)*(IM-IL)
0267      WY=W+WW
0268      D=SQRT(WY)
0269      IAA=IL
0270      JBB=JL
0271      I=IL-1
0272      J=JL+1
0273      K=0
0274      KK=5
0275      718 IF((A(I,J)-3))709,710,709
C      CALCULATE THE DISTANCE BETWEEN BOUNDARY AND CENTER POINT
0276      709 W=(I-IM)*(I-IM)
0277      WW=(JM-J)*(JM-J)
0278      WY=W+WW
0279      B=SQRT(WY)
0280      IF((D-B))1100,1101,1101
0281      1100 D=B
0282      IL=I
0283      JL=J
C      FINISH THE FINDING OF LARGEST AXIS OF LCIN EYE AREA IN
C      CLOCKWISE DIRECTION
0284      1101 IF((K-KK))750,751,751
0285      750 K=K+1
0286      I=I+1
0287      J=J+1
0288      IF((A(I,J)-3))711,712,711
0289      711 W=(I-IM)*(I-IM)
0290      WW=(JM-J)*(JM-J)
0291      WY=W+WW
0292      B=SQRT(WY)
0293      IF((D-B))1102,1103,1103
0294      1102 D=B
0295      IL=I
0296      JL=J
0297      1103 IF((K-KK))740,751,751
0298      740 K=K+1

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0299      I=I+1
0300      J=J-1
0301      IF((A(I,J)-3))719,720,719
0302 719    W=(I-IM)*(I-IM)
0303      WW=(JM-J)*(JM-J)
0304      WY=W+WW
0305      B=SQRT(WY)
0306      IF((D-B))1104,1105,1105
0307 1104   D=B
0308      IL=I
0309      JL=J
0310 1105   IF((K-KK))770,751,751
0311 770    K=K+1
0312      I=I-1
0313      J=J-1
0314      IF((A(I,J)-3))707,722,707
0315 707    W=(I-IM)*(I-IM)
0316      WW=(JM-J)*(JM-J)
0317      WY=W+WW
0318      B=SQRT(WY)
0319      IF((D-B))1106,1107,1107
0320 1106   D=B
0321      IL=I
0322      JL=J
0323 1107   IF((K-KK))741,751,751
0324 741    K=K+1
0325      I=I-1
0326      J=J+1
0327      GO TO 718
0328 710    J=J-1
0329      IF((A(I,J)-3))707,734,707
0330 734    J=J-1
0331 735    IF((A(I,J)-3))707,722,707
0332 738    W=(I-IM)*(I-IM)
0333      WW=(JM-J)*(JM-J)
0334      WY=W+WW
0335      B=SQRT(WY)
0336      IF((D-B))1108,1109,1109
0337 1108   D=B
0338      IL=I
0339      JL=J
0340 1109   IF((K-KK))760,751,751
0341 760    K=K+1
0342      I=I-1
0343      J=J-1
0344      GO TO 735
0345 712    I=I-1
0346      IF((A(I,J)-3))709,714,709
0347 714    I=I-1
0348      GO TO 718
0349 720    J=J+1
0350      IF((A(I,J)-3))711,728,711
0351 728    J=J+1
0352      IF((A(I,J)-3))711,712,711
0353 722    I=I+1
0354      IF((A(I,J)-3))738,739,738
0355 742    J=J+1
0356      IF((A(I,J)-3))743,744,743

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0357	743	W=(I-IM)*(I-IM)		
0358		WW=(JM-J)*(JM-J)		
0359		WY=W+WW		
0360		B=SQRT(WY)		
0361		IF((D-B))1110,1111,1111		
0362	1110	D=B		
0363		IL=I		
0364		JL=J		
	C	FINISH THE FINDING OF LARGEST AXIS OF LOIN EYE AREA IN		
	C	COUNTERCLOCKWISE DIRECTION ?		
0365	1111	IF((K-KK))771,751,751		
0366	771	K=K+1		
0367		I=I+1		
0368		J=J-1		
0369		GO TO 779		
0370	744	J=J+1		
0371		IF((A(I,J)-3))743,712,743		
0372	739	I=I+1		
0373	779	IF((A(I,J)-3))719,742,719		
0374	751	I=IAA-1		
0375		J=JB8-1		
0376		K=0		
0377		KK=5		
0378		GO TO 635		
0379	622	I=I+1		
0380		IF((A(I,J)-1))639,638,639		
0381	639	I=I+1		
0382	640	IF((A(I,J)-1))642,619,642		
0383	642	J=J+1		
0384		IF((A(I,J)-1))644,643,644		
0385	644	J=J+1		
0386		IF((A(I,J)-1))612,643,612		
0387	612	I=I-1		
0388		IF((A(I,J)-1))614,609,614		
0389	614	I=I-1		
0390	618	IF((A(I,J)-1))610,609,610		
0391	610	J=J-1		
0392		IF((A(I,J)-1))634,607,634		
0393	634	J=J-1		
0394	635	IF((A(I,J)-1))622,607,622		
0395	638	W=(I-IM)*(I-IM)		
0396		WW=(JM-J)*(JM-J)		
0397		WY=W+WW		
0398		B=SQRT(WY)		
0399		IF((D-B))1112,1113,1113		
0400	1112	C=B		
0401		IL=I		
0402		JL=J		
0403	1113	IF((K-KK))661,651,651		
0404	661	K=K+1		
0405		I=I-1		
0406		J=J-1		
0407		GO TO 635		
0408	619	W=(I-IM)*(I-IM)		
0409		WW=(JM-J)*(JM-J)		
0410		WY=W+WW		
0411		B=SQRT(WY)		
0412		IF((D-B))1114,1115,1115		

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0413      1114  O=B
0414      IL=I
0415      JL=J
0416      1115  IF((K-KK))671,651,651
0417      671  K=K+1
0418      I=I-1
0419      J=J-1
0420      IF((A(I,J)-1))622,607,622
0421      643  W=(I-IM)*(I-IM)
0422      WW=(JM-J)*(JM-J)
0423      WY=W+WW
0424      B=SQRT(WY)
0425      IF((D-B))1116,1117,1117
0426      1116  O=B
0427      IL=I
0428      JL=J
0429      1117  IF((K-KK))681,651,651
0430      681  K=K+1
0431      I=I+1
0432      J=J-1
0433      GO TO 640
0434      609  W=(I-IM)*(I-IM)
0435      WW=(JM-J)*(JM-J)
0436      WY=W+WW
0437      B=SQRT(WY)
0438      IF((D-B))1118,1119,1119
0439      1118  O=B
0440      IL=I
0441      JL=J
0442      1119  IF((K-KK))691,651,651
0443      691  K=K+1
0444      I=I+1
0445      J=J+1
0446      IF((A(I,J)-1))612,611,612
0447      611  W=(I-IM)*(I-IM)
0448      WW=(JM-J)*(JM-J)
0449      WY=W+WW
0450      B=SQRT(WY)
0451      IF((D-B))1120,1121,1121
0452      1120  O=B
0453      IL=I
0454      JL=J
0455      1121  IF((K-KK))601,651,651
0456      601  K=K+1
0457      I=I+1
0458      J=J-1
0459      IF((A(I,J)-1))620,619,620
0460      607  W=(I-IM)*(I-IM)
0461      WW=(JM-J)*(JM-J)
0462      WY=W+WW
0463      B=SQRT(WY)
0464      IF((D-B))1122,1123,1123
0465      1122  O=B
0466      IL=I
0467      JL=J
0468      1123  IF((K-KK))677,651,651
0469      677  K=K+1
0470      I=I-1

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FORTRAN IV G LEVEL 21          MAIN          DATE = 78133          13.
0471      J=J+1
0472      GO TO 618
0473      620 J=J+1
0474      IF((A(I,J)-1))628,611,628
0475      628 J=J+1
0476      IF((A(I,J)-1))612,611,612
0477      651 I=IL
0478      J=JL
C      (XID,XJD) IS THE 3/4 POINT OF LARGEST AXIS OF LOIN EYE AREA
C*****
C      FINISH THE FINDING OF 3/4 PCINT OF THE LARGEST AXIS OF LOIN
C      EYE AREA BY USING THE FIRST METHOD
C*****
C      FIND THE PERPENDICULAR LINE EQUATION
C*****
0479      XID=(IL+IM)/2
0480      XJD=(JL+JM)/2
C      (XIL,XJL) IS THE LEFT MOST BOUNDARY POINT
0481      XIL=IL
C      (XIM,XJM) IS THE MIDDLE PCINT OF THE LOIN EYE AREA
0482      XIM=IM
0483      XJL=JL
0484      XJM=JM
0485      4000 IF((XIL-XIM))1961,1962,1961
0486      1962 XIL=XIL+1
0487      1961 X=(XIL-XIM)/(XJL-XJM)
C      C IS THE SLOP OF THE LARGEST AXIS OF LOIN EYE AREA
0488      C=1/X
C
C      BB IS THE LINE EQ. WHICH IS PASSED THROUGH 3/4 POINT AND
C      PERPENDICULAR THE LARGEST AXIS OF THE LOIN EYE AREA
C
0489      BB=XID+C*XJD
C*****
C      FINISH THE FINDING OF PERPENDICULAR LINE EQUATION
C*****
0490      WRITE(6,1901) IL,JL,XIM,XJM
0491      1901 FORMAT(///,3X,'IL=',I2,3X,'JL=',I2,3X,'XIM=',F8.4,3X,'XJM=',F8.4)
0492      WRITE(6,2100) X,XID,XJD
0493      2100 FORMAT(///,3X,'X=',F9.6,3X,'XID=',F8.4,3X,'XJD=',F8.4)
0494      I=IL-1
0495      J=JL-1
0496      GO TO 535
0497      522 I=I+1
0498      IF((A(I,J)-1))539,538,539
0499      539 I=I+1
0500      540 IF((A(I,J)-1))542,519,542
0501      542 J=J+1
0502      IF((A(I,J)-1))544,543,544
0503      544 J=J+1
0504      IF((A(I,J)-1))512,543,512
0505      512 I=I-1
0506      IF((A(I,J)-1))514,509,514
0507      514 I=I-1
0508      518 IF((A(I,J)-1))510,509,510
0509      510 J=J-1
0510      IF((A(I,J)-1))534,507,534

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0511      534 J=J-1
0512      535 IF((A(I,J)-1))522,507,522
C*****
C      THE METHOD TO FIND THE INTERSECTION BETWEEN BOUNDARY AND LINE
C      EQUATION
C*****
0513      538 XJD=(I-B8)/(-C)
0514      IF((J-XJD))577,599,599
0515      577 I=I-1
0516      J=J-1
0517      GO TO 535
0518      519 XJD=(I-B8)/(-C)
0519      IF((J-XJD))571,599,599
0520      571 I=I-1
0521      J=J-1
0522      IF((A(I,J)-1))522,507,522
0523      543 XJD=(I-B8)/(-C)
0524      IF((J-XJD))581,599,599
0525      581 I=I+1
0526      J=J-1
0527      GO TO 540
0528      509 XJD=(I-B8)/(-C)
0529      IF((J-XJD))591,599,599
0530      591 I=I+1
0531      J=J+1
0532      IF((A(I,J)-1))512,511,512
0533      511 XJD=(I-B8)/(-C)
0534      IF((J-XJD))501,599,599
0535      501 I=I+1
0536      J=J-1
0537      IF((A(I,J)-1))520,519,520
0538      507 XJD=(I-B8)/(-C)
0539      IF((J-XJD))578,599,599
0540      578 I=I-1
0541      J=J+1
0542      GO TO 518
0543      520 J=J+1
0544      IF((A(I,J)-1))528,511,528
0545      528 J=J+1
0546      IF((A(I,J)-1))512,511,512
0547      599 WRITE(6,1000) I,J
0548      1000 FORMAT(///,3X,'3/4 POINT IS AT I=',I4,3X,'J=',I4)
C*****
C      FINISH THE FINDING OF INTERSECTION BETWEEN BOUNDARY AND LINE
C      EQUATION
C*****
C      FIND THE FAT THICKNESS
C*****
C      (IX,JX) IS THE INTERSECTION BETWEEN BOUNDARY AND LINE EQ.
0549      IX=I
0550      JX=J
0551      303 IF(A(I,J))301,302,301
0552      301 J=J-1
0553      GO TO 303
C      (IX,JXX) IS THE BOUNDARY BETWEEN BACKGROUND AND FAT
0554      302 IXX=I
0555      JXX=J

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C XX IS THE INITIAL FAT THICKNESS
0556 I=I+1
0557 XX=JX-J
0558 J=J+1
0559 343 IF(A(I,J))355,307,355
0560 355 J=J-1
0561 IF(A(I,J))323,307,323
0562 323 J=J-1
0563 312 IF(A(I,J))371,307,371
0564 371 J=J-1
0565 GO TO 312
0566 307 XY=I-IX
0567 XZ=J-JX
0568 XY=XY*XY
0569 XZ=XZ*XZ
0570 XS=XY+XZ
C XW IS THE FAT THICKNESS
0571 XW=SQRT(XS)
0572 IF(XW-XX)398,397,397
0573 398 XX=XW
0574 IXX=I
0575 JXX=J
0576 397 XJD=(I-BB)/(-C)
0577 IF((J-XJD))388,399,399
0578 388 J=J+1
0579 IF(A(I,J))319,307,319
0580 319 I=I+1
0581 GO TO 343
0582 399 WRITE(6,1001) I,J
C THE ANSWER BY USING FIRST METHOD
0583 1001 FORMAT(///,3X,'OUTSIDE 3/4 POINT IS AT I=',I4,3X,'J=',I4)
C THE ANSWER BY USING SECCND METHOD
0584 WRITE(6,1234) IXX,JXX
0585 1234 FORMAT(///,3X,'OUTSIDE 3/4 POINT IS AT I=',I4,3X,'J=',I4)
0586 WRITE(6,1404) XX
0587 1404 FORMAT(///,3X,'THE DISTANCE BETWEEN MEAT AND FAT IS',F12.6)
C *****
C FINISH THE FINDING OF FAT THICKNESS
C *****
0588 R=LL/XL
0589 WRITE(6,378) R
0590 378 FORMAT(///,3X,'THE RATIO BETWEEN FAT AND MEAT IS',F12.9)
0591 IF(IIX)4111,4111,4112
0592 4112 IIX=0
C *****
C FIND THE 3/4 POINT OF LARGEST AXIS OF LOIN EYE AREA BY USING
C SECOND METHOD
C *****
0593 I=IM
0594 J=JM
0595 3002 IF(A(I,J)-1)3000,3001,3000
0596 3000 J=J+1
0597 GO TO 3002
0598 3001 W=(I-IL)*(I-IL)
0599 WW=(J-JL)*(J-JL)
0600 WY=W+WW
0601 B=SQRT(WY)
0602 IMR=I

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0603      JMR=J
0604      IRR=I
0605      JRR=J
0606      NK=0
C      NKK IS THE BOUNDARY POINTS NEAR THE RIGHT MOST BOUNDARY
0607      NKK=4
0608      3012 I=I-1
0609      J=J-1
0610      IF(A(I,J)-1)3003,3008,3003
0611      3003 J=J+1
0612      IF(A(I,J)-1)3005,3008,3005
0613      3005 J=J+1
0614      IF(A(I,J)-1)3007,3008,3007
0615      3007 I=I+1
0616      3008 NK=NK+1
0617      IF((NK-NKK)3009,3009,3010
0618      3009 W=(I-IL)*(I-IL)
0619      WW=(J-JL)*(J-JL)
0620      WY=W+WW
0621      BC=SQRT(WY)
0622      IF((B-BC)3011,3012,3012
0623      3011 B=BC
0624      IRR=I
0625      JRR=J
0626      GO TO 3012
0627      3010 NK=0
0628      NKK=10
0629      I=IMR
0630      J=JMR
0631      3120 J=J-1
0632      IF(A(I,J)-1)3300,3109,3300
0633      3300 I=I+1
0634      IF(A(I,J)-1)3100,3109,3100
0635      3100 J=J+1
0636      IF(A(I,J)-1)3102,3109,3102
0637      3102 J=J+1
0638      IF(A(I,J)-1)3104,3109,3104
0639      3104 I=I-1
0640      3109 NK=NK+1
0641      IF((NK-NKK)3209,3209,3121
0642      3209 W=(I-IL)*(I-IL)
0643      WW=(J-JL)*(J-JL)
0644      WY=W+WW
C      BC IS THE DISTANCE OF LARGEST AXIS
0645      BC=SQRT(WY)
0646      IF((B-BC)3111,3120,3120
0647      3111 B=BC
0648      IRR=I
0649      JRR=J
0650      GO TO 3120
C      3/4 PCINT OF LARGEST AXIS OF LOIN EYE , USING THE SECCND
C      METHOD
0651      3121 XID=0.25*(IRR-IL)+IL
0652      XJD=0.25*(JRR-JL)+JL
C *****
C      FINISH THE FINDING OF 3/4 PCINT OF THE LARGEST AXIS CF LOIN E
C      AREA BY USING THE SECOND METHOD
C *****

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0653      XIL=IL
0654      XIM=IRR
0655      XJL=JL
0656      XJM=JRR
0657      I=IL
0658      J=JL
0659      GO TO 4000
0660      4111 STOP
0661      END
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AUTOMATED PATTERN RECOGNITION
OF BEEF

by

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

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Manhattan, Kansas

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In this report algorithms are presented which may be used in automatic grading of beef. Quantities such as fat thickness and meat areas are computed from digitized images of cuts of beef. This is done by tracing out the boundaries of meaty regions and finding the areas within. These algorithms are intended for use in a real-time microprocessor grading system. Results obtained indicates that automatic meat grading is comparable in accuracy to human grading.