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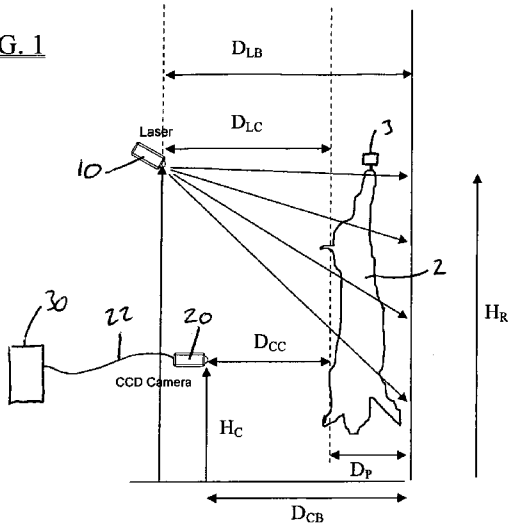
(54) **Title**: ASSESSMENT OF ANIMALS AND CARCASSES

FIG. 1



(57) **Abstract**: A method of assessing an animal or carcass comprises: projecting at least one line onto the animal or carcass by non-uniformly illuminating the animal or carcass, the line is projected onto the animal or carcass from a first direction; detecting at least part of the projected line using a detector which detects the line from a second direction, the second direction being different from the first direction; and assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

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ASSESSMENT OF ANIMALS AND CARCASSES

Field

The present disclosure relates to assessment of animals and carcasses and especially but not exclusively to methods of, and apparatus for, assessing animals and/or carcasses using analysis of illumination projected onto the animal or carcass body.

Background

The value of livestock destined for meat production and of animal carcasses is highly dependent upon body composition, and one important factor is the fat content, and in particular the fat content of certain regions of the animal or carcass. It is desirable to asses each individual animal or carcass so that, for example, a suitable price can be paid (or charged) for each animal or carcass, rather than attributing the same price to animals of differing real value. Direct measurement of fat content of each individual animal or carcass is impracticable.

Various techniques have been used to assess animals and carcasses, and one known technique involves the use of an ultrasound probe in order to assess animal tissues from the animal or carcass exterior. However, there is room for an improved or at least alternative assessment method.

Summary

According to a first aspect of the present disclosure there is provided a method of assessing an animal or carcass comprising:

projecting at least one line onto the animal or carcass by non-uniformly illuminating said animal or carcass, the line being projected onto the animal or

carcass from a first direction;

detecting at least part of at least one of the projected lines using a detector which detects line from a second direction, the second direction being different from the first direction;

assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

Preferably the step of projecting at least one line onto the animal or carcass comprises projecting at least one line which is substantially transverse to the animal or carcass. In this context transverse to the animal or carcass means in a direction perpendicular to the length of the animal or carcass.

Preferably the step of assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line comprises performing the assessment on an image of the animal or carcass with the at least one line projected thereon.

Preferably the step of assessing the body composition using the relative positions of at least two spaced apart points on the line comprises using a point substantially on the longitudinal centreline of the animal or carcass as one of the at least two points.

Preferably the step of assessing the body composition using the relative positions of at least two spaced apart points on the line comprises assessing the displacement between at least two of the points, in a direction parallel to the longitudinal centreline of the animal or carcass, as detected by the detector.

Preferably the step of assessing the body composition using the relative positions of at least two spaced apart points on the line comprises using the displacement between at least two of the points, in a direction parallel to the longitudinal centreline of the animal or carcass, as detected by the detector, as a

measure of the leanness of the animal or carcass.

Preferably the step of assessing the body composition comprises using the displacement between at least two of the points, in a direction parallel to the longitudinal centreline of the animal or carcass, as a measure of the leanness of the animal or carcass without creating a three dimensional model of the animal or carcass or part thereof.

Preferably the method includes the step of using image analysis techniques to determine the outline of the carcass.

Preferably the method includes the step of using the outline to determine specific anatomical measurements from the outline. The specific anatomical measurements may include one or more of widths and positions of the waist, chest, shoulder etc.

The step of using the outline to determine specific anatomical measurements from the outline preferably comprises detecting one or more minima and/or maxima in the width of the outline and relating corresponding anatomical features to said one or more minima and/or maxima.

Preferably the method includes the step of using determined anatomical features to generate reference data which are overlaid onto image data of the animal or carcass.

Preferably the method includes using the overlaid reference data to identify points on the projected lines for use in assessing the animal or carcass.

Preferably the overlaid reference data include one or more reference lines oriented generally in the longitudinal direction of the animal or carcass.

Preferably, said reference lines are determined relative to the carcass outline.

Preferably, said reference lines are determined relative to the carcass centerline.

In one embodiment, one or more reference lines

are lines on the torso which lie a predetermined proportion of the distance between an outer line of the body or carcass and a centreline of the body or carcass.

In an embodiment at least one reference line is a line which lies mid way between an outer line of the body or carcass and a centreline of the body or carcass. In an embodiment two reference lines are provided which each lie mid way between an outer line of the body or carcass and a centreline of the body or carcass, and which may be regarded as quarter width and three-quarter width lines.

In an embodiment at least part of one reference line is provided between the outlines of the two outer sides of the legs.

Preferably the method includes the step using image analysis techniques to extract the projected light stripe lines from the image and to identify these lines.

Preferably the method includes the step of mapping of the lines using a coordinate system.

Preferably the method includes the step of determining which projected light stripe lines are of potential interest.

Preferably the method includes the step of determining which projected light stripe lines are of potential interest by relating the light stripe lines to anatomical data extracted from the image of the animal or carcass.

Preferably the step of determining which projected light stripe lines are of potential interest comprises relating the light stripe lines to anatomical data extracted from the image of the animal or carcass by analysis of the outline of the image.

Preferably the analysis of the outline of the image of the animal or carcass comprises identifying one or more anatomical features by analysis of one or more maxima and/or minima in the width of the animal or carcass as represented in the image.

Preferably the step of determining which

projected light stripe lines are of potential interest comprises relating the light stripe lines to the overlaid reference data.

Preferably the step of determining which projected light stripe lines are of potential interest comprises identifying one or more light stripe lines which intersect the reference lines oriented generally in the longitudinal direction of the animal or carcass.

The method may comprise the step of determining the positions of a plurality of points, on the one or more light stripe lines that are determined to be of potential interest, and extracting position data relating to the relative positions of said points.

Preferably the position data is related to the surface shape of the animal or carcass at, or in the region of the points.

Preferably the position data comprises position data relating to the curvature of the projected lines on the image.

Preferably the method includes the step of using the position data to determine a number of anatomical measurements.

The anatomical measurements may comprise one or more of the following: the radius of curvature of the projected lines just above and below the chest, distance between two projected lines at the waist, the angle between the midpoint and two longitudinal line intercepts across the shoulder.

Preferably the method includes the step of generating information regarding body composition from the position data.

Preferably the method includes the step of generating information regarding body composition from the position data using an algorithm or equation.

Preferably the algorithm or equation is predetermined.

Preferably the algorithm or equation is

predetermined by a determination method comprising:

analysing images of a number of animals or carcasses of a sample group, using image analysis of light lines projected onto said animals or carcases, to generate position data relating to points on the projected lines for each member of the sample group;

using the position data to determine a number of anatomical measurements for each member of the sample group;

assessing correlation between each of the anatomical measurements for each member of the sample group and a separately measured body composition characteristic of that member of the sample group; and

generating the algorithm or equation, using anatomical measurements as variables, based on the assessed correlation of the anatomical measurements and the body composition characteristic.

Preferably the determination method comprises selecting a number of anatomical measurements for use as variables in the equation or algorithm, based on the strength of the correlation of those anatomical measurements with the body composition characteristic.

Preferably the number of anatomical measurements selected for use as variables in the equation or algorithm is small compared to the total number of anatomical measurements assessed.

Preferably the number of anatomical measurements selected for use as variable in the equation or algorithm is less than ten percent of the total number of anatomical measurements assessed.

Preferably the step of projecting at least one line onto the animal or carcass comprises projecting at least one reference line onto the animal or carcass which extends in the longitudinal direction of the animal or carcass.

Preferably at least one point used for assessing the body composition of the animal or carcass is defined

by an intersection of a projected line and a reference line.

Preferably the first direction is a direction which is not substantially transverse to at least one line projected onto a part of the animal or carcass which is being measured.

Preferably the second direction is a direction which is substantially transverse to at least one line projected onto a part of the animal or carcass which is being measured.

The, or at least one, line may be a substantially continuous line.

The, or at least one, line may be a broken line.

The, or at least one, line may comprise a number of spaced apart dots or line segments.

Preferably the step of projecting at least one line onto the animal or carcass comprises projecting at least one line using a collimated light source. In one alternative the step of projecting at least one line onto the animal or carcass comprises projecting at least one line using a focused light source.

Preferably the step of projecting at least one line onto the animal or carcass comprises projecting at least one line using a laser.

Preferably the step of projecting at least one line onto the animal or carcass comprises projecting a plurality of lines onto the animal or carcass.

Preferably the method comprises assessing the body composition of the animal or carcass by assessment of a number of regions, based on detection of respective projected lines projected onto the animal or carcass at or adjacent those respective regions.

Preferably the method further comprises measuring the length of the animal or carcass and using the length to assist in the composition analysis.

Preferably the method further comprises measuring the width of the animal or carcass and using the width to

assist in the composition analysis.

Preferably the method further comprises measuring the weight of the animal or carcass and using the weight to assist in the composition analysis.

The method may comprise:

performing additional analysis of the body composition of the animal or carcass by an additional technique; and

using the additional analysis, in combination with measurements obtained by using the relative positions of at least two spaced apart points on the line, to assess body composition.

The additional technique may comprise a technique which does not utilise the lines projected onto the animal or carcass.

The additional technique may comprise a technique which utilises ultrasound assessment of the animal or carcass.

The additional technique may comprise a measurement of fat depth on the animal or carcass.

The additional technique may comprise a measurement of fat depth at a predetermined position on the animal or carcass.

The predetermined position may be the P2 site.

The method may comprise use of an apparatus in accordance with the third aspect.

According to a second aspect of the present disclosure there is provided a determination method for determining an algorithm or equation for use in assessing a body composition characteristic of animals or carcasses, the method comprising:

analysing images of a number of animals or carcasses of a sample group, using image analysis of light lines projected onto said animals or carcases, to generate position data relating to points on the projected lines for each member of the sample group;

using the position data to determine a number of

anatomical measurements for each member of the sample group;

assessing correlation between each of the anatomical measurements for each member of the sample group and a separately made measurement of the body composition characteristic of that member of the sample group; and

generating the algorithm or equation, using anatomical measurements as variables, based on the assessed correlation of the anatomical measurements and the body composition characteristic.

Preferably the determination method comprises selecting a number of anatomical measurements for use as variables in the equation or algorithm, based on the strength of the correlation of those anatomical measurements with the body composition characteristic.

Preferably the number of anatomical measurements selected for use as variable in the equation or algorithm is small compared to the total number of anatomical measurements assessed.

Preferably the number of anatomical measurements selected for use as variable in the equation or algorithm is less than ten percent of the total number of anatomical measurements assessed.

According to a third aspect of the present disclosure there is provided apparatus for assessing an animal or carcass comprising:

at least one projector for projecting at least one line onto the animal or carcass by non-uniformly illuminating said animal or carcass, the projector being arranged to project the line onto the animal or carcass from a first direction;

a detector for detecting at least part of at least one of the projected lines the detector being arranged to detect the at least one line from a second direction, the second direction being different from the first direction;

a communication channel for communicating information relating to the at least one detected line from the detector to a computing apparatus; and

a computing apparatus for assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

Preferably the at least one projector comprises a laser.

Preferably the apparatus comprises plurality of projectors.

Preferably the apparatus comprises at least three projectors.

In an apparatus which comprises a plurality of projectors two or more respective projectors may be for projecting lines onto respective different parts of the animal or carcass.

In an apparatus which comprises a plurality of projectors two or more respective projectors may be lasers.

The detector may be a camera.

The detector may be a digital camera.

Preferably the apparatus is adapted to perform the method in accordance with the first aspect.

According to a fourth aspect of the present disclosure there is provided a computer readable medium or media, for use in assessing an animal or carcass, comprising computer readable instructions which when executed allow a computer system to:

(a) receive an image of an animal or carcass, the image having been obtained by:

(i) projecting at least one line onto the animal or carcass by non-uniformly illuminating said animal or carcass, the line being projected onto the animal or carcass from a first direction; and

(ii) detecting at least part of at least one of the projected lines using a detector which detects line

from a second direction, the second direction being different from the first direction; and

(b) perform the step of assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line;

such that the obtaining of the image and performance of the step of assessing the body composition of the animal or carcass using the relative positions of said at least two spaced apart points on the line, result in performance of a method in accordance with the first aspect.

According to a fifth aspect of the present disclosure there is provided a computer readable medium or media, for use in assessing an animal or carcass, comprising:

(a) computer readable instructions which when executed allow a computer system to:

(i) receive an image of an animal or carcass onto which at least one line has been projected by non uniformly illuminating said animal or carcass, the line having been projected onto the animal or carcass from a first direction, the image having been obtained by a detector which detects at least a part of at least one of the projected lines from a second direction, the second direction being different from the first direction; and,

(ii) assess the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to:

use determined anatomical features to generate reference data which are overlaid onto the image of the animal or carcass;

use the overlaid reference data to identify points on the projected lines for use in assessing the

animal or carcass; and

wherein the overlaid reference data include one or more reference lines oriented generally in the longitudinal direction of the animal or carcass.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to determine said reference lines relative to the carcass outline.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to determine said reference lines relative to the carcass centerline.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to determine said reference lines which are lines on the torso which lie a predetermined proportion of the distance between an outer line of the body or carcass and a centreline of the body or carcass.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to determine said reference lines wherein at least one reference line is a line which lies mid way between an outer line of the body or carcass and a centreline of the body or carcass.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to use image analysis techniques to extract the projected light stripe lines from the image and to identify these lines.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to:

map the lines using a coordinate system; and

determine which projected light stripe lines are of potential interest by relating the light stripe lines to anatomical data extracted from the image of the animal

or carcass.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to determine which projected light stripe lines are of potential interest by relating the light stripe lines to anatomical data extracted from the image of the animal or carcass by analysis of the outline of the image.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to analyse the outline of the image of the animal or carcass by identifying one or more anatomical features by analysis of one or more maxima and/or minima in the width of the animal or carcass as represented in the image.

In an embodiment the computer readable medium or media further comprises computer readable instructions which when executed allow a computer to determine which projected light stripe lines are of potential interest by relating the light stripe lines to the overlaid reference data.

According to a sixth aspect of the present disclosure there is provided a computer readable medium or media, for use in assessing an animal or carcass, comprising computer readable instructions which when executed allow a computer system to perform the determination method in accordance with the second aspect.

It will be appreciated that features which are set out above in relation to a particular aspect may be applicable (or indicate analogous features which may be applicable) to one or more other aspects.

Brief Description of the Drawings

Embodiments of aspects of the present disclosure will be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a diagrammatic illustration of part of

an apparatus for use in an assessment method, with a carcass positioned for assessment;

Fig. 2 is an illustration of a practical embodiment of the apparatus of Fig. 1;

Fig. 3 is a photographic representation of a carcass with transverse lines, or light stripes, projected thereon;

Fig. 4 is an illustration of the transverse lines, or light stripes, of Fig. 3 as detected by the detector of Fig. 1;

Fig. 5 is a diagrammatic illustration of a silhouette of the carcass illustrated in Fig. 1, as detected by the detector of Fig. 1;

Fig. 6 is an illustration of an example of a set of maxima and minima of the width of the carcass which identify definable anatomical features of the carcass;

Fig. 7 is an illustration of an example of a set of longitudinal reference lines generated and overlaid onto the image of the carcass of Fig. 5;

Fig. 8 is an illustration of generated longitudinal reference lines intersecting transverse lines projected onto a relatively lean carcass, as might be detected by the detector;

Fig. 9 is an illustration of generated longitudinal reference lines intersecting transverse lines projected onto a less lean carcass, as might be detected by the detector;

Fig. 10 is an enlargement of part of Fig. 9, more clearly showing the intersections of the projected transverse lines and the longitudinal reference lines, and illustrates a more preferred example of transverse lines, or light stripes, as detected by the detector of Fig. 1;

Fig. 11 is a block diagram illustrating an example of a method of analysis of the projected lines;

Fig. 12 is a representation of a carcass illustrating points on the carcass identified and used for analysis and assessment of the carcass; and

Fig. 13 illustrates determination of a radius of curvature of part of the carcass.

Description of embodiments

With reference to Fig.s 1 and 2, an embodiment of apparatus for assessing an animal or carcass 2 comprises at least one projector which in this embodiment is in the form of an array 10 of three lasers 10A, 10B, 10C, each of which is for projecting a number of lines, or light stripes, onto the carcass 2. Techniques and apparatus for splitting a beam of light (such as collimated light, a focussed beam, or a beam from a laser) into a number of lines are known per se and will not be described herein, but it will be appreciated that in the illustrated embodiment the array 10 comprises a suitable beam splitter, associated with each laser, which splits the beam into number of parallel lines. The apparatus further comprises a detector, which in this embodiment is in the form of a CCD camera 20, for detecting the projected lines. The carcass 2 is suspended vertically by a support 3, which may be a hook or any other supporting mechanism. The camera 20 is provided at a height H_C and the lasers are provided at a different height H_R so that each line is projected onto the carcass 2 from a first direction and detected from a second direction, the second direction being different from the first direction. This means that the shape of the lines, as detected by the camera 20 will be dependent upon the shape of the surface of the carcass 2 onto which they are projected.

The apparatus further comprises a communication channel, in the form of a camera cable 22 for transmitting image data to a computer 30 which can analyse the image data to automatically assess the body composition of the animal or carcass (as will be described hereafter).

As illustrated, the horizontal distance between the camera 20 and the carcass 2 is D_{CC} and the horizontal

distance between the projector array 10 and the carcass 2 is D_{LC}. Other measurements shown in Fig. 1 (D_{CB}, D_{LB} and D_P) are considered self explanatory and may be useful to know in relation to setting up the apparatus and/or image analysis.

These parameters are used by the computer 30, in analysing the lines to assess body composition.

With reference to Fig.2, an example of a support structure 5 for supporting and spacing apart the lasers 10A, 10B, 10C and the camera 20 will be described. The support structure 5 comprises a camera platform 24, which in this embodiment is in the form of a metal plate to which the camera 20 is secured by a suitable mounting (not shown). The support structure 5 further comprises a projector platform 14, which in this embodiment is in the form of a metal plate. The camera platform 24 and projector platform 14 are vertically spaced apart. In the illustrated embodiment, the camera platform 24 and projector platform 14 are vertically spaced apart by a plurality of vertically oriented lower connecting rods 26A, 26B, 26C, 26D, which have external screw threads at their ends and which are connected to the camera platform 24 and projector platform 14 by passing through apertures (not shown) therein, and secured by securing nuts, eg 28A, 28C. In this embodiment the vertical spacing between the camera platform 24 and projector platform 14 is adjustable by operation of the securing nuts, eg 28A, 28C. In a preferred version of this embodiment the spacing can be varied between about 1400mm (corresponding to a lower level of the camera 20) and 1100mm (corresponding to a higher level of the camera 20).

The support structure 5 further comprises a support plate 6 which is attached to a ceiling mounting plate 7. In the illustrated embodiment, the support plate 6 is attached to a ceiling mounting plate 7 by a mounting bolt 8 which passes though apertures (not shown) generally centrally of the support plate 6 and ceiling mounting

plate 7.

The projector platform 14 is supported below, and vertically spaced apart from, the support plate 6. In the illustrated embodiment, the projector platform 14 is vertically spaced apart from the support plate 6 by a plurality of vertically oriented upper connecting rods 16A, 16B, 16C which have external screw threads at their ends and which are connected to the projector platform 14 and support plate 6 by passing through apertures (not shown) therein, and secured by securing nuts, eg 18A, 18C.

It will be appreciated that in the illustrated embodiment, as described above, it was desired that the vertical spacing between camera platform 24 and projector platform 14 be adjustable, and that the vertical spacing between the projector platform 14 and the support plate 6 be adjustable, and use of threaded rods and nuts, eg 18A, 18C facilitated this. In a commercial embodiment one or both of these vertical spacings may be fixed (and, indeed, it is considered desirable that the vertical spacing between camera platform 24 and projector platform 14 be fixed) so that alternative, non-adjustable spacing structures may be preferred. Further, in a commercial embodiment robustness and protection of the apparatus are important, and a metal casing which protects the apparatus and provides a spacing structure (in particular, for the camera platform and projector platform) is considered a useful feature.

It will be appreciated that the array 10 can project a large number of transverse lines onto the carcass 2.

It will further be appreciated that the lines are, generally, projected from an upwards direction (ie, projected downwardly, from the array 10, since the array 10 is approximately at or above the level of the top of the part of the carcass 2 at which measurements are to be taken) and detected by the camera 20 from a level or downwards direction (since the camera 20 is approximately

at or below the level of the bottom of the part of the carcass 2 at which measurements are to be taken).

It will thus be appreciated that the shape variation, in a transverse direction, of a part of the carcass upon which a transverse line is projected will affect the shape of the line, as viewed by the detector. More specifically, the extent to which a part of the carcass upon which a transverse line is projected is convex or concave will vary the apparent curvature of the line.

As illustrated in Fig. 3, with reference to parts of the carcass 2 which are close to a longitudinal centreline 40 thereof, a region which is concave, eg region 42 is characterised by a line, eg line 44, which is detected as being lower at its centre and rising with distance away from its centre. In contrast, a region which is convex, eg region 46 is characterised by a line, eg line 48, which is detected as being higher at its centre and descending with distance away from its centre. Thus the shape of a line, and more specifically the variation of longitudinal displacement from its centre as it extends transversely away from its centre, accurately indicates how concave or convex is the corresponding part of the carcass. It will further be appreciated that the degree to which various regions of the carcass are concave or convex will depend to a great extent on the composition of the body, and especially the amount of fat carried. Thus, using suitable reference tables and calculation, the shape of a line at a known part of the carcass (and more specifically the variation of longitudinal displacement from its centre, that is the carcass centreline, as it extends transversely away from its centre) can accurately indicate body composition.

Fig. 4 shows the transverse lines of Fig. 3 in isolation.

In a preferred embodiment, the measurement and assessment of the lines and their shapes is facilitated by

generating longitudinal reference lines and overlaying them on the image of the carcass. The intersections between the reference lines and the projected transverse lines provide useful reference points to assist assessment. For example, the displacement in the 'height' direction (which corresponds to the longitudinal direction of the carcass) between a point where a transverse line intersects the carcass centreline and a point where the transverse line intersects one of the longitudinal lines which is laterally spaced from the centreline can be used to asses the degree to which that part of the carcass is concave or convex, and thus to assess body composition.

As illustrated in Fig. 5, a silhouette of the carcass is obtained.

Fig. 6 illustrates how the silhouette of a carcass can be straightforwardly analysed by finding maxima and minima in the carcass width to provide measurements of the carcass which relate to certain predictable regions. As illustrated in Fig.6, the width maxima and minima allow identification and measurement of: butt width 50 (first maximum); waist width 52 (first minimum); chest width 54 (second maximum); upper chest width 56 (second minimum); and, shoulder width 58 (third, bottom, maximum). Measuring the distances between these minima and maxima allows measurement of: butt to shoulder length; butt to waist length 60; butt to chest length; butt to upper chest length; waist to chest length 62; waist to upper chest length; waist to shoulder length; chest to upper chest length 64; chest to shoulder length; and, upper chest to shoulder length.

As illustrated in Fig. 7, suitable longitudinal reference lines are generated and overlaid onto the carcass image. Generation of the longitudinal lines will be discussed in more detail in due course.

Fig. 8 shows generated longitudinal reference lines intersecting transverse lines projected onto a relatively lean carcass as would be detected by the camera

20.

Fig. 9 shows generated longitudinal reference lines intersecting transverse lines projected onto a less lean carcass as would be detected by the camera 20.

Fig. 10 is an enlargement of part of Fig. 9, more clearly showing the intersections of the projected transverse lines and the longitudinal reference lines. As can be seen, the intersections are easily detectable by image analysis software, and thus measurements at these points can easily be made automatically. From these measurements, with suitable reference material and/or algorithms, assessment of body composition can be made.

Light stripe measures have been shown, on a small sample, to be as accurate as ultrasound techniques in predicting lean meat yield. The light stripe analysis can automatically and almost instantaneously measure a considerable number of locations, and can therefore assess differently proportioned individuals in a manner that ultrasound techniques (which tend to focus measurements at a single location) cannot. When combined with ultrasound measurements to predict lean meat yield, the overall prediction accuracy improves further.

Fig 11 illustrates, in block diagram form, steps used in determining lean meat yield of carcases.

The analysis begins (block 102) by obtaining an image of a carcass, upon which are projected distinguishable, non-crossing lines (e.g. a series of parallel lateral lines projected from a laser or a collimated light source onto the carcass, as described above) against a contrasting background. An outline of the carcass is determined (block 103) by image analysis techniques which are known per se.

The outline is used to determine anatomically significant features, including, e.g, the longitudinal lines shown in Fig.s 7 to 10 (block 104). The longitudinal lines can be determined relative to the carcass outlines and centerlines. In the illustrated embodiment, the

longitudinal lines are determined as midlines between the outlines and the centerline of the carcass for the torso region (which may be regarded as quarter and three quarter lines), and between the outlines of the two sides of the legs. One contribution of these particular longitudinal reference lines is to assist in identifying which features (points on the light stripes) pertain to the left or right side of the carcass, and concomitantly, being located sufficiently and relatively distant from the centerline so that later measures are not predominantly covering an anatomical region where left and right sections are difficult to distinguish. The reference lines are used (in conjunction with the detected transverse lines, as will be described hereafter) for image analysis, as will be discussed below.

From the image, minima and maxima in the width of the carcass are determined (block 105) and measured, to identify the anatomical features as described above with reference to Fig. 6.

It will be appreciated that determination of the anatomical features of the carcass allows measurements to be taken at desired anatomical positions (as will be described hereafter).

Image analysis techniques which are known per se are used to extract the light stripe lines from the image, (e.g. Niblack threshold, background threshold or color threshold) and to identify these lines (block 106).

Mapping of the lines (x-y coordinates) is determined by, for example, determining the midline through the area covered by each line (block 107).

The resultant lines are smoothed (block 108) using smoothing algorithms (known per se) to reduce the noise in later assessment.

Projected light lines that have had local breaks due to discrepancies in the carcass (e.g. from skin wrinkles, bruises or blotches) can be joined (block 109) to assist later analysis.

Projected lines that are projected onto the previously determined (at block 104) anatomical features are selected (ie, in this embodiment, certain projected lines which intersect the longitudinal lines). Projected lines which do not intersect the longitudinal lines and/or which are not positioned in useful positions relative to the previously determined anatomical features may be eliminated from the image (block 110).

A number of points, for use in the carcass analysis, are identified on the projected the light stripe lines (block 111). For example, maximum/minimum x-coordinate (height/longitudinal) and y-coordinate (width/lateral) values, mid-points of one or more lines, saddle points, and points where the transverse lines intersect the longitudinal lines may be identified for use in carcass analysis.

A number of point and distance measurements are created (block 112), using the points determined in block 111 and geometric analysis and techniques which are known per se, are used to determine measurements of the displacement between points on the image of the carcass surface. The displacement of certain points has a relationship to the shape of the surface of the carcass. For example, x-coordinate and/or y-coordinate distances between the midpoint of a transverse line and the longitudinal line intersect points may be used. Further detail will be provided with reference to Fig. 12.

Shape measurements (such as radius of curvature of a specific region of the carcass) using three points, and angles between three points, are determined (block 113) using geometric formula (eg as described below) and the points and distances determined at blocks 111 and resultant points measured at block 112.

A number and variety of relative anatomical measurements are then determined (block 114) using the anatomical measurements from block 104 and the measurements determined in blocks 110 to 113. For example,

the measurements may comprise: radius of curvature of the lines just above and below the chest; the distance between two lines at the waist; the angle between the midpoint and the two longitudinal-line intercepts across the shoulder, etc. These anatomical measurements can be presented as a results spreadsheet (block 115) and used to provide a determination of lean meat yield of a carcass, as will be described below. Of course results can be presented in a manner other than as a spreadsheet if desired.

It will be appreciated that the functions and steps set out in Fig. 11 will, in an illustrative embodiment, be performed by a suitably programmed computer, such as computer 30 illustrated schematically in Fig. 1. Thus although the present disclosure describes a method which includes projecting light stripes onto a carcass and detecting the stripes, for example by use of camera 20, the assessment of the data after capture, in order to assess an animal or carcass, is (on its own) also a significant part of the present disclosure. The illustrated operations and processes can be implemented as computer-readable instructions stored on a computer-readable medium. The computer-readable instructions can be executed by a processor of any suitable computing device.

If desired, examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. Designing or obtaining a suitable computer, and/or writing (or having a programmer write) the code for the software and or firmware would be within the skill of one of skilled in the art in light of this disclosure. A typical computer system generally includes one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors,

computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or keyboard. A typical data processing system may be implemented utilizing any suitable commercially available components, such as those typically found in data computing/communication and/or network computing/ communication systems.

Because of the harsh conditions which occur in a meat processing environment, in an illustrative embodiment a 'Harsh Environment Computer' is used. Such Harsh Environment Computers are known per se, may include a stainless steel casing, and other design characteristics that help mitigate the challenges of a harsh environment. Because image capture and analysis plays a prominent part in the assessment disclosed herein, a frame grabber card (such as, for example, the National Instrument NI-1410 frame grabber card) is included in an illustrative computer 30.

The measurement/analysis method described above can be used to develop a large number of measurements that can be used in regression equations to predict dependent variables such as lean meat yields, cuts yields etc. That is, a large number of measurements are taken of a sample comprising a number of carcasses of the type to be assessed (preferably specific to animal variety, and most preferably specific to the population from which the carcasses to be assessed are to taken). The body composition of the sample carcasses is then assessed as accurately as possible using alternative techniques. The emphasis is on accuracy for this assessment, and it does not matter if rather laborious techniques (such as intrusive physical assessment) are used, since a small sample (relative to the numbers to be assessed commercially) is being assessed. A mathematical analysis

is then performed to determine which of the many measurements (or which combinations of those measurements) most accurately correspond to the actual body composition of the carcasses of the sample. This identifies measurements (and relationships between those measurements) which can be used to accurately assess body composition on a commercial scale. This technique has been found to provide accurate body composition analysis using the light stripe techniques described above. Further because only a few relatively simple measurements need be taken when the technique is implemented on a commercial scale (in contrast to, for example, creating a full 3D model of each carcass) the method does not require undue image processing, or processing time and can therefore be performed quickly and efficiently on a commercial scale.

The measurements which most accurately correspond to actual body composition have been found to vary with animal variety, and even geographically different populations of the same variety. Thus for optimum accuracy a suitable sample group of carcasses should be used, as discussed above. It is considered a strength of this approach that the measurements and calculations can effectively be calibrated for different varieties and populations to provide good accuracy, rather than, for example calculating body composition based on approximations which are intended to apply to many different varieties.

Fig. 12 illustrates, by way of example, some points on a carcass image which may be used to establish measurements which can be used in body composition analysis as disclosed herein. The eleven points, designated P1 to P11 may be defined as follows:

P1 - Centre of waist (CW);

P2 - Centre of Upper Line (CU);

P3 - Centre of Lower Line (CL);

P4 - Upper Max Left (UML);

P5 - Upper Max Right (UMR);
P6 - Lower Max Left (LML);
P7 - Lower Max Right (LMR);
P8 - Upper Left Wing (ULW);
P9 - Upper Right Wing (URW);
P10 - Lower Left Wing (LLW); and
P11 - Lower Right Wing (LRW).

Measurements can be derived from the positions of these points, as set out in Table 1, in which w_n denotes an nth width or lateral measurement, h_n denotes an nth height or longitudinal measurement, x_n denotes an x-coordinate of point Pn and y_n denotes a y-coordinate of point Pn.

Furthermore, the radius of curvature R (as illustrated in Fig. 13) of transverse cross sectional regions of the carcass on which measurements are made can be determined, as also set out in Table 1. The values for radius of curvature R at a position corresponding to three laterally aligned points on the carcass can be determined by calculations based on those points.

The radius of curvature can be determined algebraically using the three equations for R, x_C and y_C shown in Table 1, and using any three appropriate points (x_1,y_1), (x_2,y_2) and (x_3,y_3). Here, R is the radius of curvature, and x_C and y_C are the coordinate values of the centre of the circle (see Fig 13). R1 to R4 are representative values using various points from Figure 12, but are not the only ones available. For example, $R_1 = Radius_{2,5,9}$ is the radius of curvature using points P2, P5 and P9. Thus the value of R_1 can be determined using the equations set out in the right-hand column of Table 1, substituting the respective x and y values for points P2, P5 and P9.

a_{jkl} represents the angle subtended when going from points j to k to l, given the following conditions

y_k is between the y values of the other two points (i.e. $y_j>y_k>y_l$ or $y_j<y_k<y_l$)

x_k is to the left or right of both of the other points (i.e. $x_k>x_j,x_l$ or $x_k<x_j,x_l$)

An example of this is $a_1=a_{6,10,11}$, which is the angle going through points P6, P10 and P11. The angle, $a_{jkk'}$ represents the angle between the line going from points j to k and the horizontal line going through the point k. An example of this is $a_3=a_{6,3,3'}$, which is the angle between the line going through points P6 and P3 and the horizontal line going through P3.

TABLE 1

$w_1 = x_7 - x_3$ $w_2 = x_3 - x_6$ $w_3 = x_7 - x_6$ $w_4 = x_{11} - x_3$ $w_5 = x_3 - x_{10}$ $w_6 = x_{11} - x_{10}$ $w_7 = x_{11} - x_7$ $w_8 = x_6 - x_{10}$	$w_{11} = x_5 - x_2$ $w_{12} = x_2 - x_4$ $w_{13} = x_5 - x_4$ $w_{14} = x_9 - x_2$ $w_{15} = x_2 - x_8$ $w_{16} = x_9 - x_8$ $w_{17} = x_9 - x_5$ $w_{18} = x_4 - x_8$	$h_1 = y_3 - y_7$ $h_2 = y_3 - y_6$ $h_3 = y_7 - y_6$ $h_4 = y_{11} - y_3$ $h_5 = y_{10} - y_3$ $h_6 = y_{11} - y_{10}$ $h_7 = y_{11} - y_7$ $h_8 = y_{10} - y_6$ $h_9 = y_1 - y_3$	$h_{11} = y_2 - y_5$ $h_{12} = y_2 - y_4$ $h_{13} = y_5 - y_4$ $h_{14} = y_9 - y_2$ $h_{15} = y_8 - y_2$ $h_{16} = y_9 - y_8$ $h_{17} = y_9 - y_5$ $h_{18} = y_8 - y_4$ $h_{19} = y_2 - y_1$
$R_1 = \text{Radius}_{2,5,9}$ $R_2 = \text{Radius}_{2,4,8}$ $R_3 = \text{Radius}_{3,7,11}$ $R_4 = \text{Radius}_{3,6,10}$	$R=\sqrt{(x_1-x_c)^2+(y_1-y_c)^2}$ $x_c=\frac{(y_1-y_3)(x_1^2-x_2^2+y_1^2-y_2^2)-(y_1-y_2)(x_1^2-x_3^2+y_1^2-y_3^2)}{2((y_1-y_3)(x_1-x_2)-(y_1-y_2)(x_1-x_3))}$ $y_c=\frac{x_1^2-x_2^2+y_1^2-y_2^2-2x_c(x_1-x_2)}{2(y_1-y_2)}$		
$a_1=a_{6,10,11}$ $a_2=a_{7,11,10}$ $a_3=a_{6,3,3'}$ $a_4=a_{7,3,3'}$ $a_5=a_{4,8,9}$ $a_6=a_{5,9,8}$ $a_7=a_{4,2,2'}$ $a_8=a_{5,2,2'}$ $a_9=a_{4,2,5}$ $a_{10}=a_{6,3,7}$	$a_{jkl}=\left\lvert\tan^{-1}\frac{y_j-y_k}{x_j-x_k}\right\rvert+\left\lvert\tan^{-1}\frac{y_k-y_l}{x_k-x_l}\right\rvert$ $a_{jkk'}=\left\lvert\tan^{-1}\frac{y_j-y_k}{x_j-x_k}\right\rvert$		

It will be apparent that because of the large number and variety of measurements to choose from, because the measurements and relationships used are determined recursively in order to obtain a good predictive fit based empirically on a sample group of carcasses and because different species and varieties have differing proportions and fat/muscle distributions, it is not meaningful to define the invention in terms of a single equation or set of relationships or proportionalities. However, by way of example, a trial has established set of relations applicable to a particular sample group which can effectively predict Lean Meat Yield of pig carcasses, as follows:

LMY = - 0.209 - 0.00566 P2 Fat Depth + 0.000981 R4 - 0.00458 h3 - 0.00215 Upper Chest Width + 0.00229 Shoulders Width

It will thus be apparent that this equation utilises a separate measurement of fat depth at the P2 site. Although considered beneficial to include this variable, it will be appreciated from the foregoing description that this is not essential. By way of illustration, one example of regression analysis results for assessing lean meat yield (LMY) based on the anatomical features and without a separate independent measurement (such as P2 fat depth), are as follows:

The regression equation is

TtlCT%LMY = 0.710 - 0.00283 Waist - 0.00376 Upper Chest + 0.00482 Shoulders+ 0.000698 UCtC

Predictor	Coef	SE Coef	T	P
Constant	0.7104	0.1124	6.32	0.000
Waist	-0.0028293	0.0006873	-4.12	0.001
Upper Chest	-0.0037637	0.0008263	-4.55	0.000
Shoulders	0.0048179	0.0007282	6.62	0.000
UCtC	0.0006977	0.0002173	3.21	0.006

S = 0.0190935 R-Sq = 78.1% R-Sq(adj) = 72.2%

It will also be appreciated by the skilled addressee that it may be useful to include the length and/or weight of the carcass as variables in the analysis. The length can be determined by the image analysis software. The weight can be measured prior to the projection of light lines onto the carcass, or simultaneously if a weighing mechanism is incorporated in the equipment which supports the carcass.

It will be appreciated that the described embodiments and examples can provide an effective means of carcass assessment which is readily employable in commercial meat processing environments, and on a commercial scale.

Modifications and improvements may be incorporated without departing from the scope of the present invention.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or in any other country.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS

1. A method of assessing an animal or carcass comprising:

projecting at least one line onto the animal or carcass by non-uniformly illuminating said animal or carcass, the line being projected onto the animal or carcass from a first direction;

detecting at least part of at least one projected line using a detector which detects the line from a second direction, the second direction being different from the first direction; and

assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

2. A method according to claim 1 wherein the step of projecting at least one line onto the animal or carcass comprises projecting at least one line which is substantially transverse to the animal or carcass.

3. A method according to either preceding claim wherein the step of assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line comprises assessment of an image of the animal or carcass with the at least one line projected thereon.

4. A method according to any preceding claim wherein the step of assessing the body composition using the relative positions of at least two spaced apart points on the line comprises using a point substantially on the longitudinal centreline of the animal or carcass as one of the at least two points.

5. A method according to any preceding claim wherein the step of assessing the body composition using the relative positions of at least two spaced apart points on the line comprises assessing the displacement between at least two of the points, in a direction parallel to the longitudinal centreline of the animal or carcass, as detected by the detector.

6. A method according to claim 5, wherein the step of assessing the body composition using the relative positions of at least two spaced apart points on the line comprises using the displacement between at least two of the points, in a direction parallel to the longitudinal centreline of the animal or carcass, as detected by the detector, as a measure of the leanness of the animal or carcass.

7. A method according to claim 6, wherein the step of assessing the body composition comprises using the displacement between at least two of the points, in a direction parallel to the longitudinal centreline of the animal or carcass, as a measure of the leanness of the animal or carcass without creating a three dimensional model of the animal or carcass or part thereof.

8. A method according to any preceding claim wherein the method includes the step of using image analysis techniques to determine the outline of the carcass.

9. A method according to claim 8, wherein the method includes the step of using the outline to determine specific anatomical measurements from the outline.

10. A method according to claim 9, wherein the specific anatomical measurements include one or more of widths and positions of the waist, chest and/or shoulder.

11. A method according to any of claims 8 to 10, wherein the step of using the outline to determine specific anatomical measurements from the outline comprises detecting one or more minima and/or maxima in the width of the outline and relating corresponding anatomical features to said one or more minima and/or maxima.

12. A method according to any preceding claim wherein the method includes the step of using determined anatomical features to generate reference data which are overlaid onto image data of the animal or carcass.

13. A method according to claim 12 wherein the

method includes using the overlaid reference data to identify points on the projected lines for use in assessing the animal or carcass.

14. A method according to claim 13, wherein the overlaid reference data include one or more reference lines oriented generally in the longitudinal direction of the animal or carcass.

15. A method according to claim 14, wherein said reference lines are determined relative to the carcass outline.

16. A method according to either of claims 14 or 15, wherein said reference lines are determined relative to the carcass centerline.

17. A method according to any of claims 14 to 16, wherein one or more reference lines are lines on the torso which lie a predetermined proportion of the distance between an outer line of the body or carcass and a centreline of the body or carcass.

18. A method according to claim 17, wherein at least one reference line is a line which lies mid way between an outer line of the body or carcass and a centreline of the body or carcass.

19. A method according to any of claims 12 to 18 wherein the method includes the step of using image analysis techniques to extract the projected light stripe lines from the image data and to identify these lines.

20. A method according to claim 19, wherein the method includes the step of mapping of the lines using a coordinate system.

21. A method according to either of claims 19 or 20 wherein the method includes the step of determining which projected light stripe lines are of potential interest.

22. A method according to claim 21, wherein the method includes the step of determining which projected light stripe lines are of potential interest by relating the light stripe lines to anatomical data extracted from

the image of the animal or carcass.

23. A method according to claim 22, wherein the step of determining which projected light stripe lines are of potential interest comprises relating the light stripe lines to anatomical data extracted from the image of the animal or carcass by analysis of the outline of the image.

24. A method according to claim 23, wherein the analysis of the outline of the image of the animal or carcass comprises identifying one or more anatomical features by analysis of one or more maxima and/or minima in the width of the animal or carcass as represented in the image.

25. A method according to any of claims 21 to 24, when dependent upon any one of claims 12 to 18, wherein the step of determining which projected light stripe lines are of potential interest comprises relating the light stripe lines to the overlaid reference data.

26. A method according to any of claims 21 to 25, wherein the step of determining which projected light stripe lines are of potential interest comprises identifying one or more light stripe lines which intersect reference lines oriented generally in the longitudinal direction of the animal or carcass.

27. A method according to any of claims 21 to 26 wherein the method may comprise the step of determining the positions of a plurality of points, on the one or more light stripe lines that are determined to be of potential interest, and extracting position data relating to the relative positions of said points.

28. A method according to claim 27, wherein the position data is related to the surface shape of the animal or carcass at, or in the region of the points.

29. A method according to either of claims 27 or 28 wherein the position data comprises position data relating to the curvature of the projected lines on the image.

30. A method according to any of claims 27 to

29, wherein the method includes the step of using the position data to determine a number of anatomical measurements.

31. A method according to claim 30, wherein the anatomical measurements comprise one or more of the following: the radius of curvature of the projected lines just above and below the chest, distance between two projected lines at the waist, the angle between the midpoint and two longitudinal line intercepts across the shoulder.

32. A method according to claims 27 to 31, wherein the method includes the step of generating information regarding body composition from the position data.

33. A method according to claim 32 wherein the method includes the step of generating information regarding body composition from the position data using an algorithm or equation.

34. A method according to claim 33 wherein the algorithm or equation is predetermined.

35. A method according to claim 34 wherein the algorithm or equation is predetermined by a determination method comprising:

analysing images of a number of animals or carcasses of a sample group, using image analysis of light lines projected onto said animals or carcases, to generate position data relating to points on the projected lines for each member of the sample group;

using the position data to determine a number of anatomical measurements for each member of the sample group;

assessing correlation between each of the anatomical measurements for each member of the sample group and a separately measured body composition characteristic of that member of the sample group; and

generating the algorithm or equation, using anatomical measurements as variables, based on the

assessed correlation of the anatomical measurements and the body composition characteristic.

36. A method according to claim 35 wherein the determination method comprises selecting a number of anatomical measurements for use as variables in the equation or algorithm, based on the strength of the correlation of those anatomical measurements with the body composition characteristic.

37. A method according to claim 36 wherein the number of anatomical measurements selected for use as variables in the equation or algorithm is small compared to the total number of anatomical measurements assessed.

38. A method according to claim 37 wherein the number of anatomical measurements selected for use as variable in the equation or algorithm is less than ten percent of the total number of anatomical measurements assessed.

39. A method according to claim 38 wherein the step of projecting at least one line onto the animal or carcass comprises projecting at least one reference line onto the animal or carcass which extends in the longitudinal direction of the animal or carcass.

40. A method according to claim 39 wherein at least one point used for assessing the body composition of the animal or carcass is defined by an intersection of a projected line and a reference line.

41. A method according to any preceding claim, wherein the first direction is a direction which is not substantially transverse to at least one line projected onto a part of the animal or carcass which is being measured.

42. A method according to claim 41 wherein the second direction is a direction which is substantially transverse to at least one line projected onto a part of the animal or carcass which is being measured.

43. A method according to any preceding claim wherein the, or at least one, line is a substantially

continuous line.

44. A method according to any preceding claim wherein the, or at least one, line is a broken line.

45. A method according to any preceding claim where the, or at least one, line comprises a number of spaced apart dots or line segments.

46. A method according to any preceding claim, wherein the step of projecting at least one line onto the animal or carcass comprises projecting at least one line using a collimated light source.

47. A method according to any preceding claim, wherein the step of projecting at least one line onto the animal or carcass comprises projecting at least one line using a focused light source.

48. A method according to any preceding claim wherein the step of projecting at least one line onto the animal or carcass comprises projecting at least one line using a laser.

49. A method according to any preceding claim wherein the step of projecting at least one line onto the animal or carcass comprises projecting a plurality of lines onto the animal or carcass.

50. A method according to any preceding claim wherein the method comprises assessing the body composition of the animal or carcass by assessment of a number of regions, based on detection of respective projected lines projected onto the animal or carcass at or adjacent those respective regions.

51. A method according to any preceding claim wherein the method further comprises measuring the length of the animal or carcass and using the length to assist in the composition analysis.

52. A method according to any preceding claim wherein the method further comprises measuring the width of the animal or carcass and using the width to assist in the composition analysis.

53. A method according to any preceding claim

wherein the method further comprises measuring the weight of the animal or carcass and using the weight to assist in the composition analysis.

54. The method according to any preceding claim wherein the method comprises:

performing additional analysis of the body composition of the animal or carcass by an additional technique; and

using the additional analysis, in combination with measurements obtained by using the relative positions of at least two spaced apart points on the line, to assess body composition.

55. A method according to claim 54, wherein the additional technique comprises a technique which does not utilise the lines projected onto the animal or carcass.

56. A method according to either of claims 54 or 55 wherein the additional technique comprises a technique which utilises ultrasound assessment of the animal or carcass.

57. A method according to any of claims 54 to 56, wherein the additional technique comprises a measurement of fat depth on the animal or carcass.

58. A method according to claim 57, wherein the additional technique comprises a measurement of fat depth at a predetermined position on the animal or carcass.

59. A method according to claim 58, wherein the predetermined position is the P2 site.

60. A determination method for determining an algorithm or equation for use in assessing a body composition characteristic of animals or carcasses, the method comprising:

analysing images of a number of animals or carcasses of a sample group, using image analysis of light lines projected onto said animals or carcases, to generate position data relating to points on the projected lines for each member of the sample group;

using the position data to determine a number of

anatomical measurements for each member of the sample group;

assessing correlation between each of the anatomical measurements for each member of the sample group and a separately made measurement of the body composition characteristic of that member of the sample group; and

generating the algorithm or equation, using anatomical measurements as variables, based on the assessed correlation of the anatomical measurements and the body composition characteristic.

61. A method according to claim 60 wherein the determination method comprises selecting a number of anatomical measurements for use as variables in the equation or algorithm, based on the strength of the correlation of those anatomical measurements with the body composition characteristic.

62. A method according to claim 61, wherein the number of anatomical measurements selected for use as variable in the equation or algorithm is small compared to the total number of anatomical measurements assessed.

63. A method according to claim 62 wherein the number of anatomical measurements selected for use as variable in the equation or algorithm is less than ten percent of the total number of anatomical measurements assessed.

64. A method according to any of claims 60 to 63, wherein the method is a method of determining an algorithm or equation for use in the method of any one of claims 1 to 59.

65. An apparatus for assessing an animal or carcass comprising:

at least one projector for projecting at least one line onto the animal or carcass by non-uniformly illuminating said animal or carcass, the projector being arranged to project the line onto the animal or carcass from a first direction;

a detector for detecting at least part of at least one of the projected lines the detector being arranged to detect the at least one line from a second direction, the second direction being different from the first direction;

a communication channel for communicating information relating to the at least one detected line from the detector to a computing apparatus; and

a computing apparatus for assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

66. An apparatus in accordance with claim 65, wherein the at least one projector comprises a laser.

67. An apparatus in accordance with either of claims 65 or 66 wherein the apparatus comprises a plurality of projectors.

68. An apparatus in accordance with claim 67 wherein the apparatus comprises at least three projectors.

69. An apparatus in accordance with either of claims 67 or 68 wherein two or more respective projectors are for projecting lines onto respective different parts of the animal or carcass.

70. An apparatus in accordance with any of claims 67 to 69 wherein two or more respective projectors comprise lasers.

71. An apparatus in accordance with any of claims 65 to 70 wherein the detector is a camera.

72. An apparatus in accordance with claim 71 wherein the detector is a digital camera.

73. An apparatus according to any one claims 65 to 72 wherein the apparatus is adapted to perform the method in accordance with any of claims 1 to 59.

74. A computer readable medium or media, for use in assessing an animal or carcass, comprising computer readable instructions which when executed allow a computer system to:

(a) receive an image of an animal or carcass, the image having been obtained by:

(i) projecting at least one line onto the animal or carcass by non-uniformly illuminating said animal or carcass, the line being projected onto the animal or carcass from a first direction; and

(ii) detecting at least part of at least one of the projected lines using a detector which detects line from a second direction, the second direction being different from the first direction; and

(b) perform the step of assessing the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line;

such that the obtaining of the image and performance of the step of assessing the body composition of the animal or carcass using the relative positions of said at least two spaced apart points on the line, result in performance of the method as claimed in any of claims 1 to 59.

75. The computer readable medium or media, of claim 74, wherein the computer readable instructions, when executed, allow a computer system to perform assessment of an animal or carcass, such that the obtaining of the image and performance of the step of assessing the body composition of the animal or carcass using the relative positions of said at least two spaced apart points on the line, result in performance of a method as claimed in any of claims 14 to 18 or 20 to 40.

76. A computer readable medium or media, for use in assessing an animal or carcass, comprising:

(a) computer readable instructions which when executed allow a computer system to:

(i) receive an image of an animal or carcass onto which at least one line has been projected by non uniformly illuminating said animal or carcass, the line having been projected onto the animal or carcass from a first direction, the image having been obtained by a

detector which detects at least a part of at least one of the projected lines from a second direction, the second direction being different from the first direction; and,

(ii) assess the body composition of the animal or carcass using the relative positions of at least two spaced apart points on the line.

77. The computer readable medium or media of claim 76, further comprising computer readable instructions which when executed allow a computer to:

use determined anatomical features to generate reference data which are overlaid onto the image of the animal or carcass;

use the overlaid reference data to identify points on the projected lines for use in assessing the animal or carcass; and

wherein the overlaid reference data include one or more reference lines oriented generally in the longitudinal direction of the animal or carcass.

78. The computer readable medium or media of claim 77, further comprising computer readable instructions which when executed allow a computer to determine said reference lines relative to the carcass outline.

79. The computer readable medium or media of either of claims 77 or 78, further comprising computer readable instructions which when executed allow a computer to determine said reference lines relative to the carcass centerline.

80. The computer readable medium or media of claims 79, further comprising computer readable instructions which when executed allow a computer to determine said reference lines which are lines on the torso which lie a predetermined proportion of the distance between an outer line of the body or carcass and a centreline of the body or carcass.

81. The computer readable medium or media of

claim 80, further comprising computer readable instructions which when executed allow a computer to determine said reference lines wherein at least one reference line is a line which lies mid way between an outer line of the body or carcass and a centreline of the body or carcass.

82. The computer readable medium or media of any of claims 77 to 81, further comprising computer readable instructions which when executed allow a computer to use image analysis techniques to extract the projected light stripe lines from the image and to identify these lines.

83. The computer readable medium or media of claim 82, further comprising computer readable instructions which when executed allow a computer to:

map the lines using a coordinate system; and

determine which projected light stripe lines are of potential interest by relating the light stripe lines to anatomical data extracted from the image of the animal or carcass.

84. The computer readable medium or media of claim 83, further comprising computer readable instructions which when executed allow a computer to determine which projected light stripe lines are of potential interest by relating the light stripe lines to anatomical data extracted from the image of the animal or carcass by analysis of the outline of the image.

85. The computer readable medium or media of claim 84, further comprising computer readable instructions which when executed allow a computer to analyse the outline of the image of the animal or carcass by identifying one or more anatomical features by analysis of one or more maxima and/or minima in the width of the animal or carcass as represented in the image.

86. The computer readable medium or media of any of claims 83 to 85, further comprising computer readable instructions which when executed allow a computer

to determine which projected light stripe lines are of potential interest by relating the light stripe lines to the overlaid reference data.

87. A computer readable medium or media, for use in assessing an animal or carcass, comprising computer readable instructions which when executed allow a computer system to perform the determination method of any of claims 60 to 64.

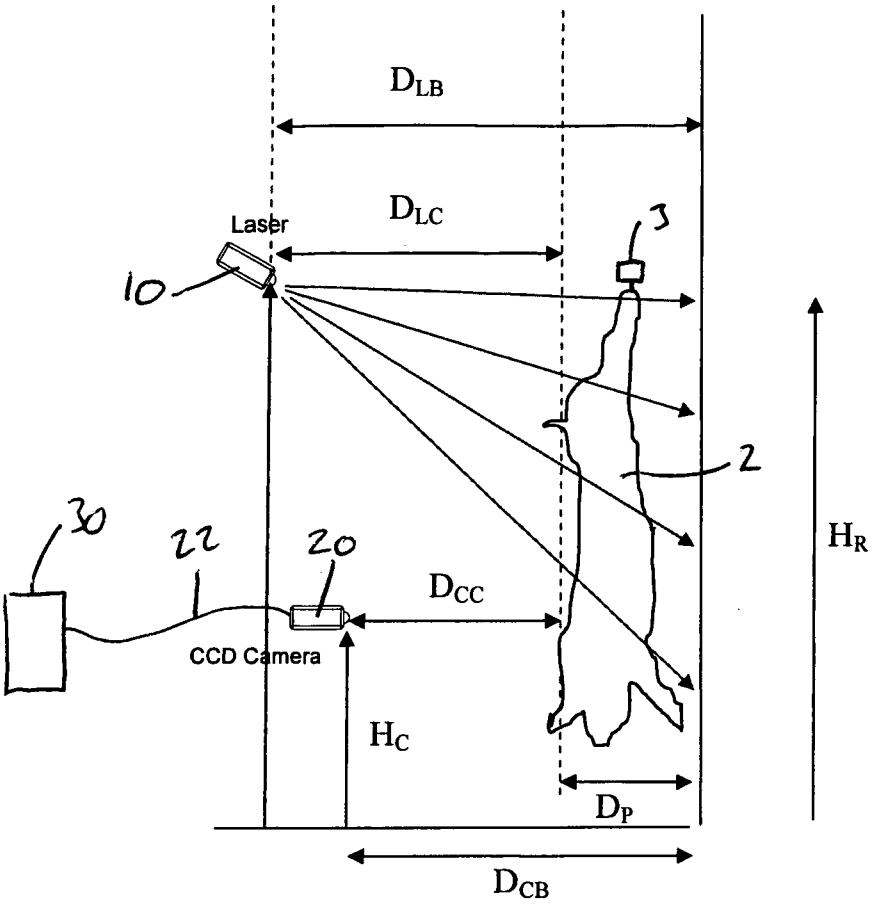


FIG. 1

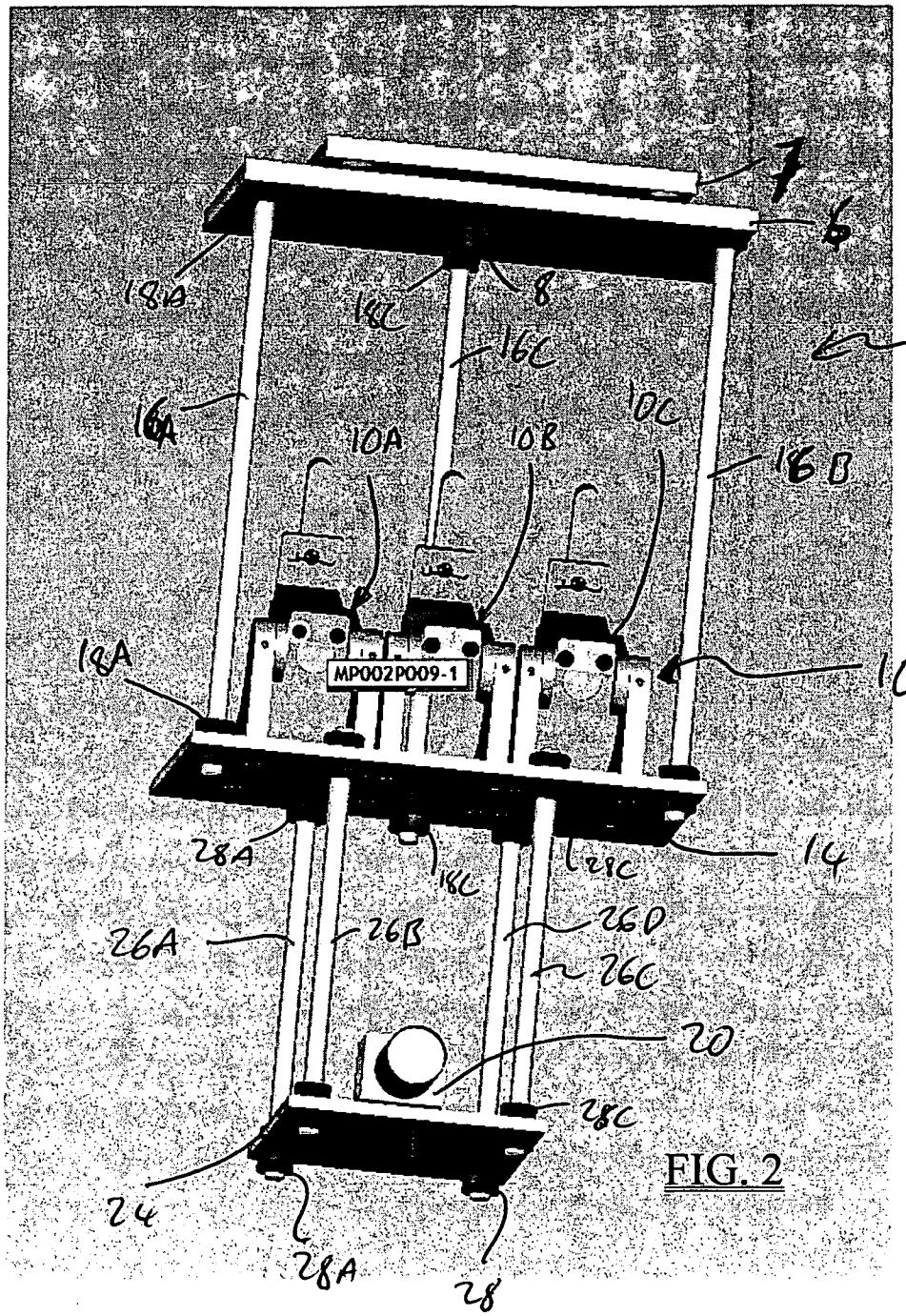

7
6
5
18B
18C
8
16C
16A
10A
10B
10C
16B
MP002P009-1
18A
10
28A
18C
28C
14
26A
26B
26D
26C
20
28C
24
28A
28

FIG. 2

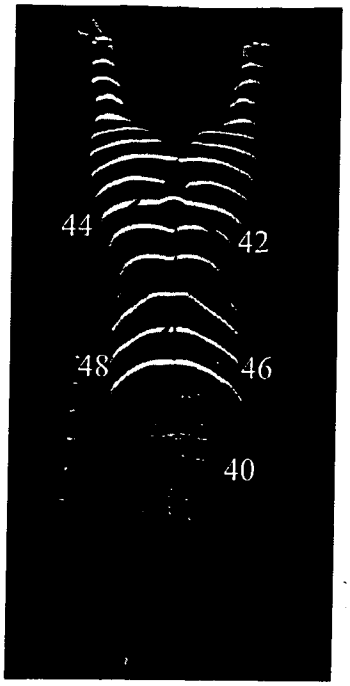


FIG. 3

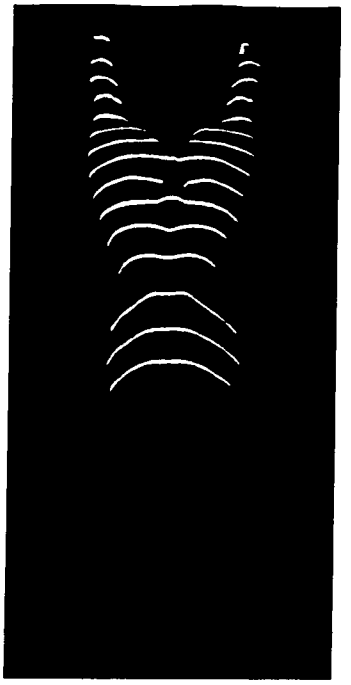


FIG. 4

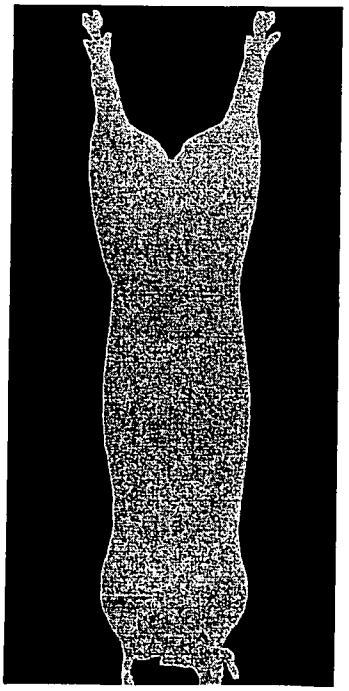


FIG. 5

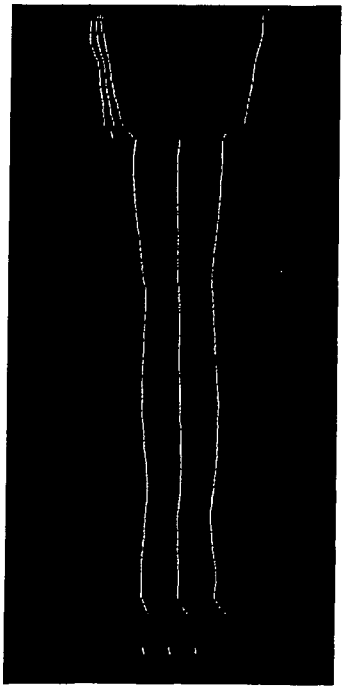


FIG.7

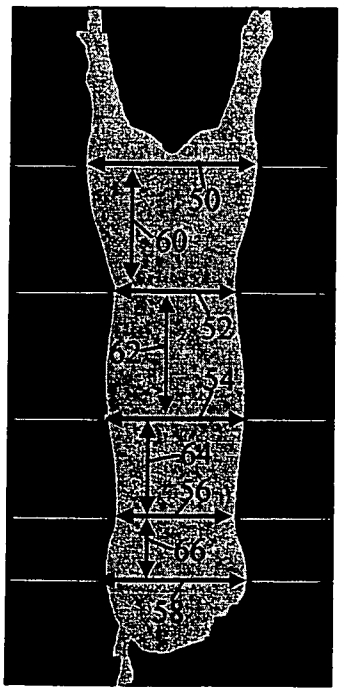


FIG.6

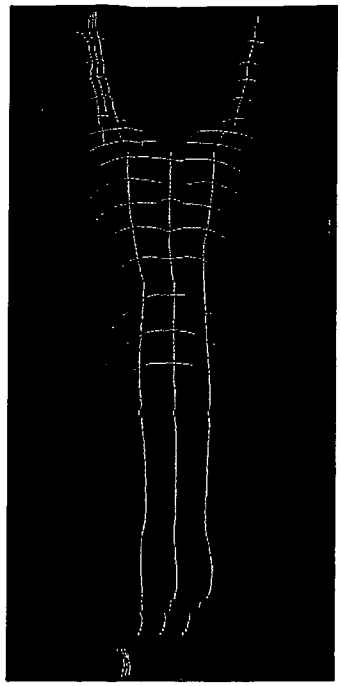


FIG. 8

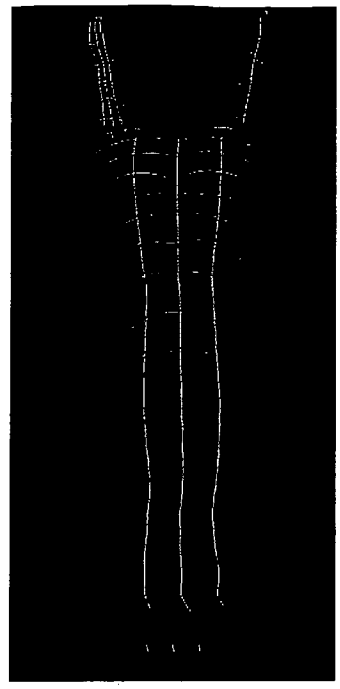
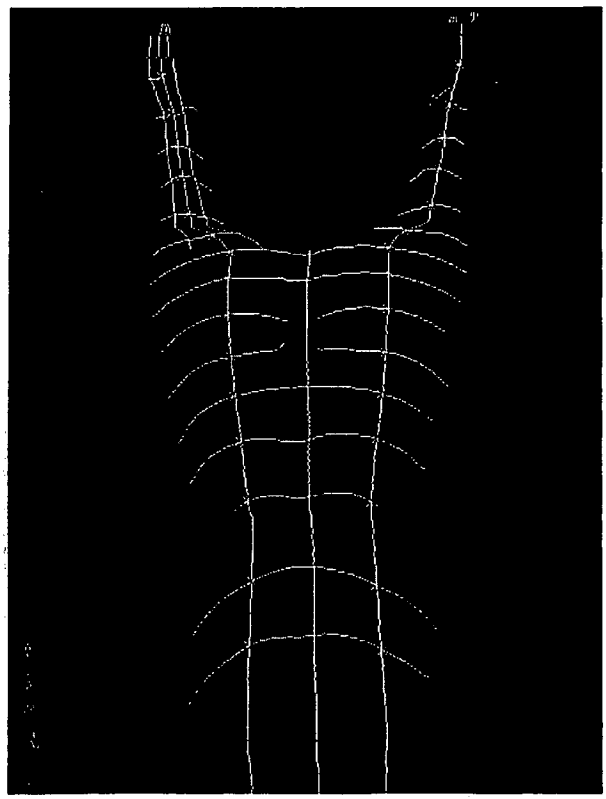


FIG. 9

FIG. 10



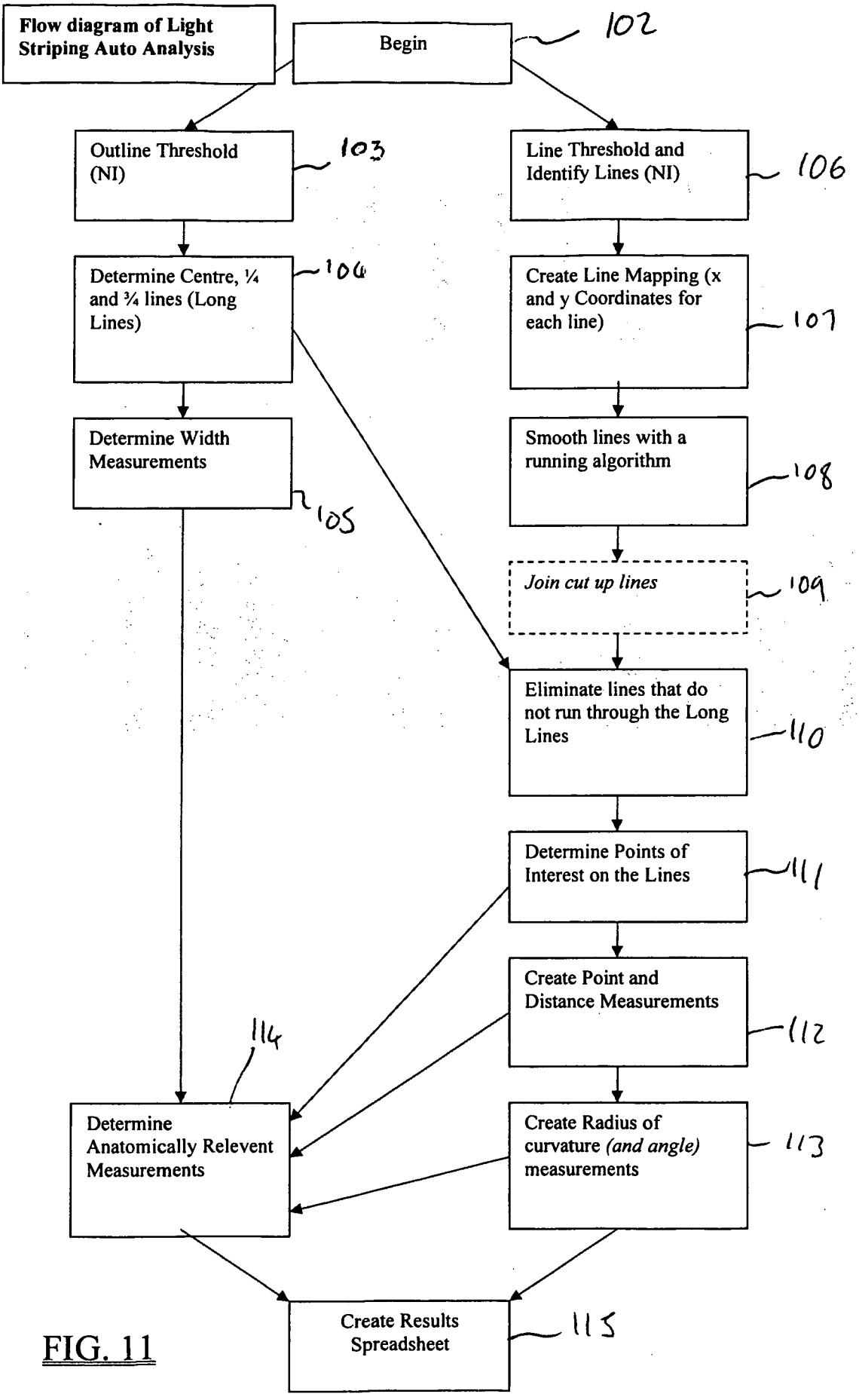
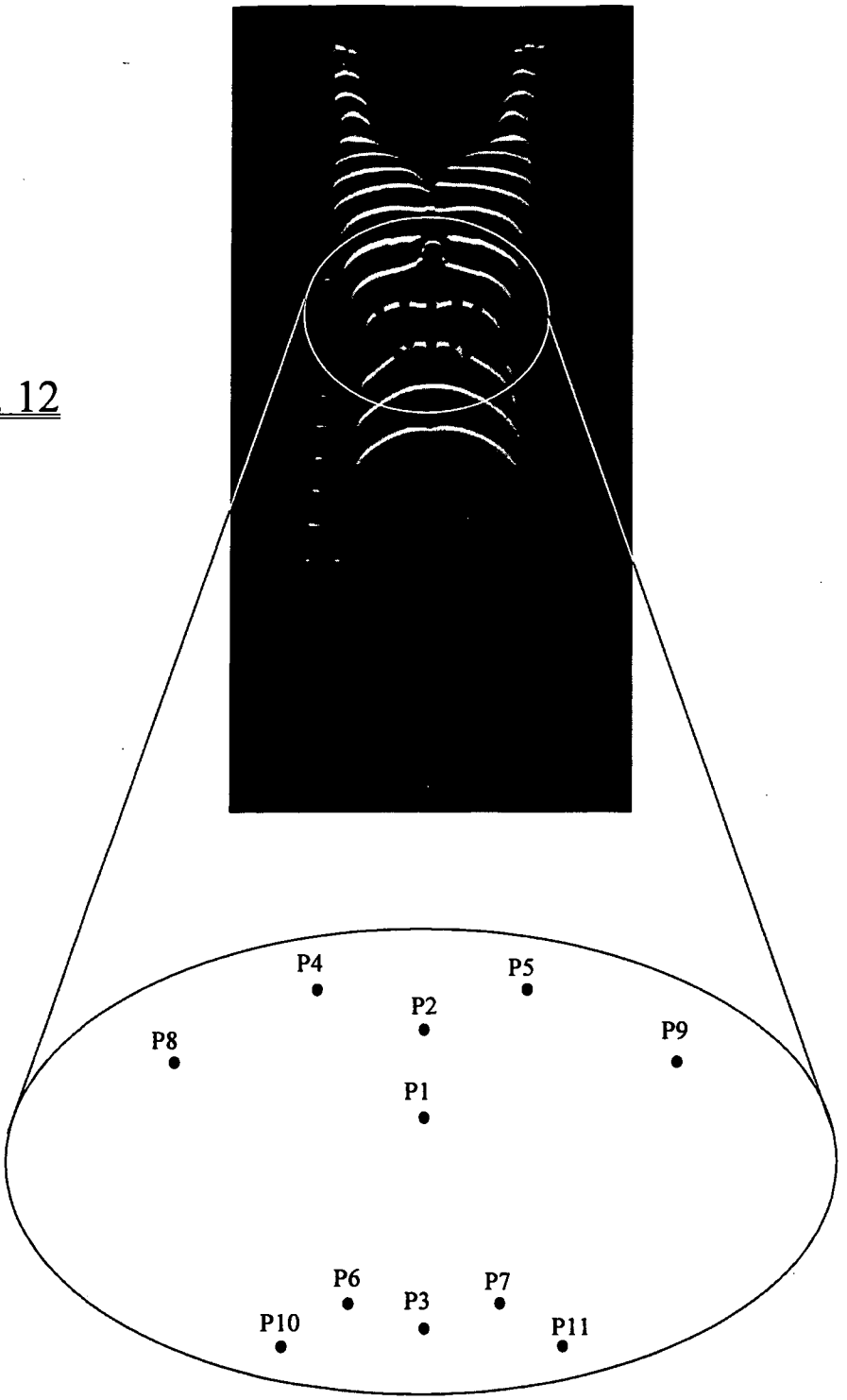

Flow diagram of Light Striping Auto Analysis
Begin
102
Outline Threshold (NI)
103
Line Threshold and Identify Lines (NI)
106
Determine Centre, ¼ and ¾ lines (Long Lines)
104
Create Line Mapping (x and y Coordinates for each line)
107
Determine Width Measurements
105
Smooth lines with a running algorithm
108
Join cut up lines
109
Eliminate lines that do not run through the Long Lines
110
Determine Points of Interest on the Lines
111
Create Point and Distance Measurements
112
114
Determine Anatomically Relevent Measurements
Create Radius of curvature (and angle) measurements
113
Create Results Spreadsheet
115

FIG. 11

FIG. 12



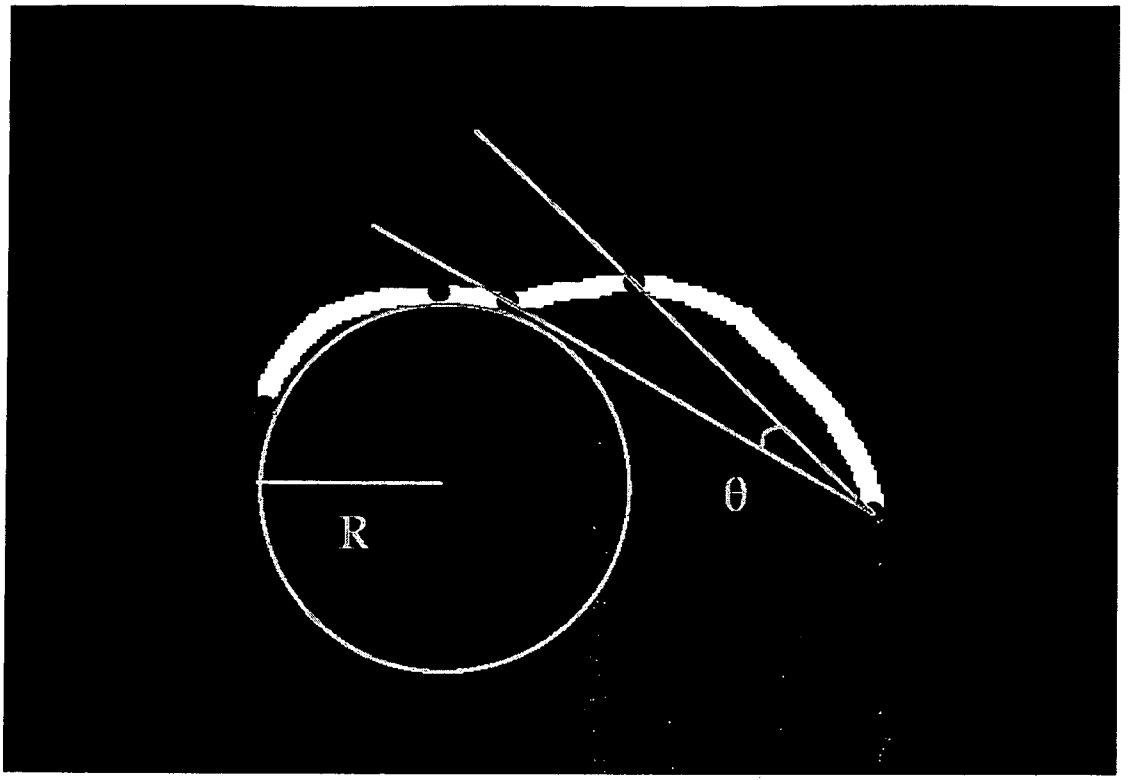


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2010/000812

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

G06K 9/36 (2006.01) ***B07C 5/10*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI: IPC: G09K 9/-, G01N 21/- or B07C 5/- with keywords: Invention I: animal, carcass, beast, project, light, illuminate, laser, beam, radiate, line, detect, image, camera, composition, characteristic, anatomy, grade, assess, analyse, compute, sort, inspect, distance, separation, relative, spacing, position, locate, scan, angle; Invention II: animal, carcass, beast, project, light, illuminate, laser, beam, radiate, line, detect, image, camera, composition, characteristic, anatomy, grade, assess, analyse, compute, sort, inspect

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 2004/0032974 A1 (KRIESEL) 19 February 1994	
X	Paragraphs [0027]-[0030], [0092]-[0110], [0121], figures 3, 4, 23, 28-30	1-11, 41-43, 46-50, 52-55, 65-76, 87
Y	Paragraph [0004]	51
	WO 2004/012146 A1 (VETTECH LTD) 5 February 2004	
X	Page 19, lines 14-27 and figures 1, 2A-2C, 5B-5D	1-3, 8-10, 11, 46-49, 65-76, 87
	US 2004/0023612 A1 (KRIESEL) 5 February 2004	
A	abstract	

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 2010	05 OCT 2010
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **KURT TOBLER** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 2469

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2010/000812

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See additional sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-59 and 65-86 are directed to a method of and apparatus for assessing an animal or carcass, comprising projecting at least one line onto the animal from a first direction, detecting the line from a second direction, and assessing the body composition using at least two spaced apart points on the line. It is considered that projecting at least one line onto the animal from a first direction, detecting the line from a second direction, and assessing the body composition using at least two spaced apart points on the line comprises a first distinguishing feature.

- Claims 60 to 64 and 87 are directed to a determination method for determining an algorithm or equation for use in assessing animals or carcasses, comprising analysing images of a number of animals of a sample group, using image analysis of light lines projected onto the animals to generate position data for anatomical measurements, assessing correlation between each member and the sample group and generating the algorithm or equation. It is considered that generating the algorithm or equation comprises a second distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

The only feature common to all of the claims is projecting a light line onto animals or carcasses to generate position data relating to points on the projected line to then determine anatomical measurements. However this concept is not novel in the light of:

US 2004/0032974 A1 (KRIESEL) .

This means that the common feature can not constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Because the common feature does not satisfy the requirement for being a special technical feature it follows that it cannot provide the necessary technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a posteriori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2010/000812

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2004032974	US	7039220				
WO	2004012146	AU	2003281732	EP	1537531	IL	166480
		US.	2006126903				
US	2004023612	US	6974373	US	2005136819	US	7214128
		US	2005257748	US	7399220		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX