RECENT PROJECTS AT MASSEY UNIVERSITY'S IMAGE ANALYSIS UNIT

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ABSTRACT

The Image Analysis Unit was established to provide a range of image analysis services. A sample of five projects from the last year are presented:

- Digital subtraction arteriography analyses a video sequence from an image-intensified X-ray fluoroscope to obtain information on blood flow in arteries in the neck and head of a young calf.
- Electron micrographs of transverse sections from horse ligaments are analysed to investigate the effect of training and injury on the density and size distribution of the collagen fibrils.
- The roughness of casein particles is determined by measuring the fractal dimension of the boundary of the silhouette.
- The concentration of proteins in a sample is measured by staining the protein and measuring the density of the stain.
- A series of photographs of waves breaking on a sandbar is corrected for perspective distortion, and analysed to see how the position and height of the bar change with time.

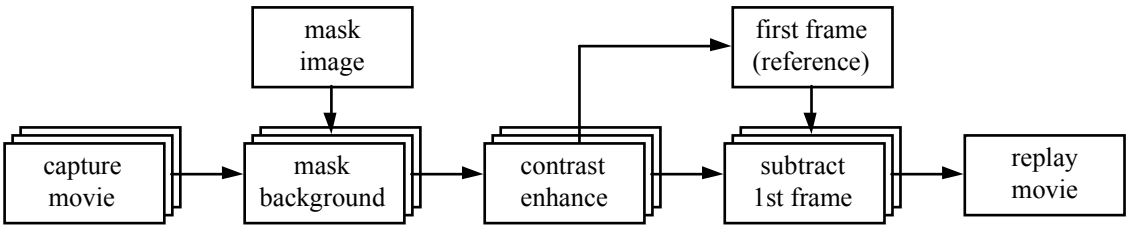
INTRODUCTION

As reported in the 3rd NZ Image Processing Workshop [1], an Image Analysis Unit was established at Massey University in 1988 to provide a focus for image analysis research and expertise, as well as providing image analysis services to the wider research community. The Unit performs this role through teaching image processing (at both undergraduate and postgraduate levels), supervision of project students (honours, masters, and PhD), and performing image analysis work on projects required for researchers (both on Massey and in the surrounding research community). This paper indicates some of the breadth of the projects performed, and describes techniques that may be of benefit to others attending the workshop.

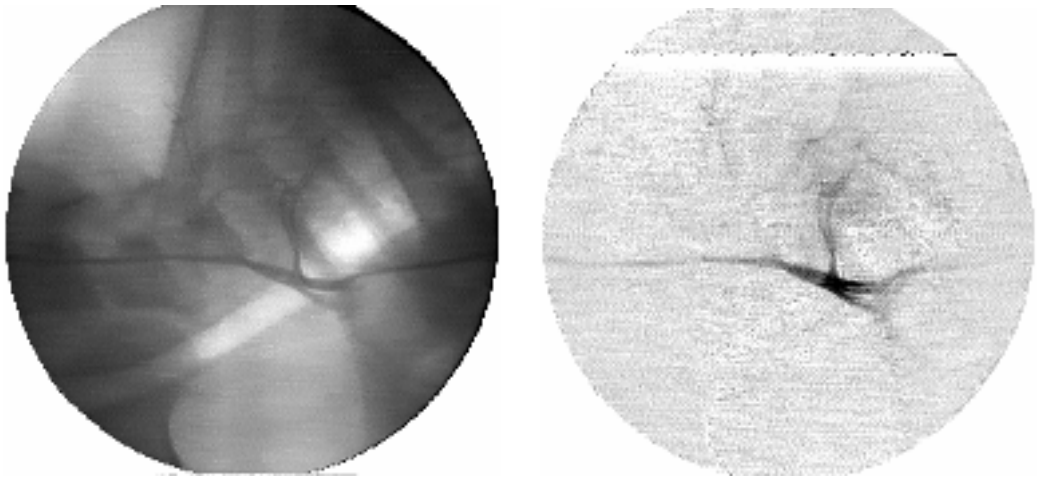
The VIPS software package [2] is used extensively within the Unit, and is the software environment used for all of the projects described. Version 4 of the software is currently being used on an Apple Macintosh IIcx, a 486 PC under Windows, and a MicroVAX II. The current version of VIPS has been considerably extended from earlier versions. Rather than give VIPS program listings for each application (some are extensive), example images and a block diagram showing the main points of each algorithm are provided.

DIGITAL SUBTRACTION ARTERIOGRAPHY

A researcher in the Department of Physiology and Anatomy was investigating the arterial distribution in young calves. By injecting a liquid radio-opaque contrast agent into a selected artery through a catheter, that artery (and the arteries downstream from that point) are made visible on an image-intensified X-ray fluoroscope. A video sequence obtained in this way shows the blood flow. From the video, a sequence of 48 frames is captured over a period of 5 to 10 seconds as the contrast agent is injected. However, in the individual frames, the arterial structure is often masked by the presence of bone and other tissues. Since the only change from frame to frame is the movement of the contrast agent as it flows through the arteries, by subtracting a reference image, the distribution of blood flow is made readily visible without the clutter of the bones. The first frame, taken before the contrast agent is injected, is used as the reference image. In this application, although the image processing is relatively straight forward, it yields spectacular results of great benefit to researchers in this area.



Algorithm used for digital subtraction arteriography



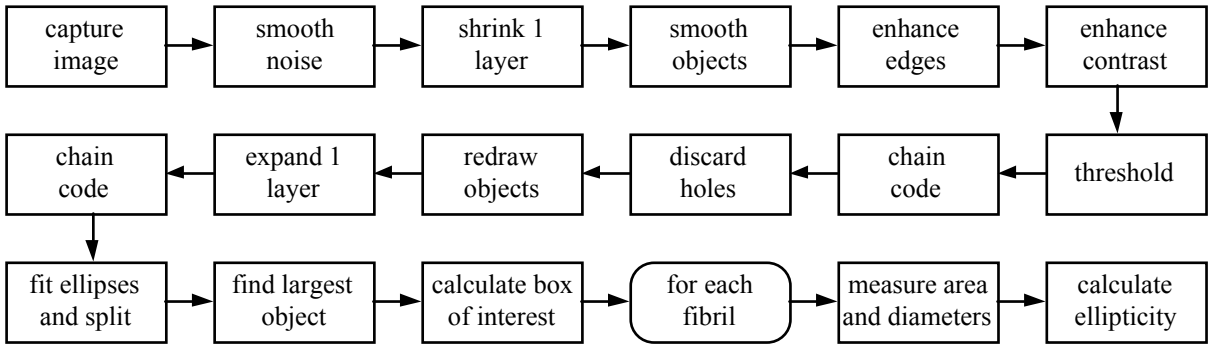
Input after injecting contrast agent (left); blood flow distribution after processing (right)

COLLAGEN FIBRIL AREA MEASUREMENT

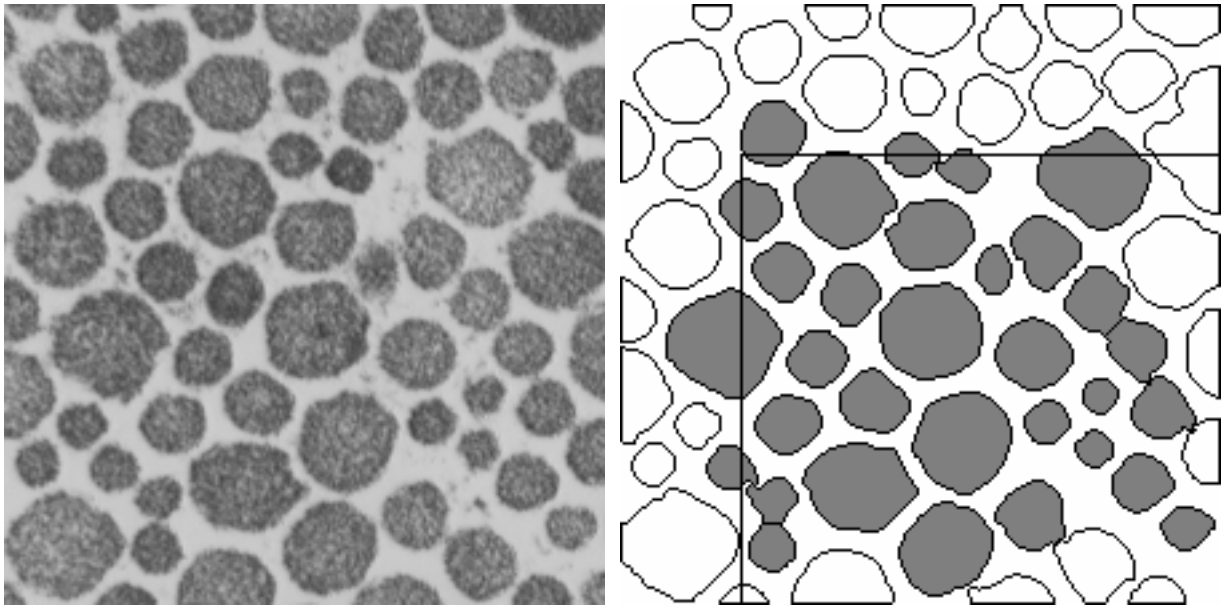
Collagen fibrils are the basic structural units of ligaments and tendons. An image is captured from an electron micrograph of a transverse section taken from a horse ligament. It is desired to investigate the effect of training and injury on the density and size distribution of the fibrils. Particular problems in this application are the high levels of noise, variations in contrast, and the close spacing of the fibrils.

The fibrils are extracted from the background by smoothing the noise in the image, enhancing edges which have been blurred [3], normalising the contrast using a local intensity stretch, and thresholding. Any holes inside the fibres are filled, and touching fibrils are separated

using an ellipse fitting technique [4]. A region of interest is determined by finding the largest height and width of fibrils within the image. Only those fibrils which are completely within the image and are within or touching the region of interest are measured. Using a region of interest in this way avoids biasing the sample towards the smaller fibrils as the larger fibrils are more likely to lie across the image boundaries. Parameters of interest are the area, diameter, and ellipticity.



Algorithm used for collagen fibril area measurement



Original image (left); after processing (right) showing region of interest and fibrils processed

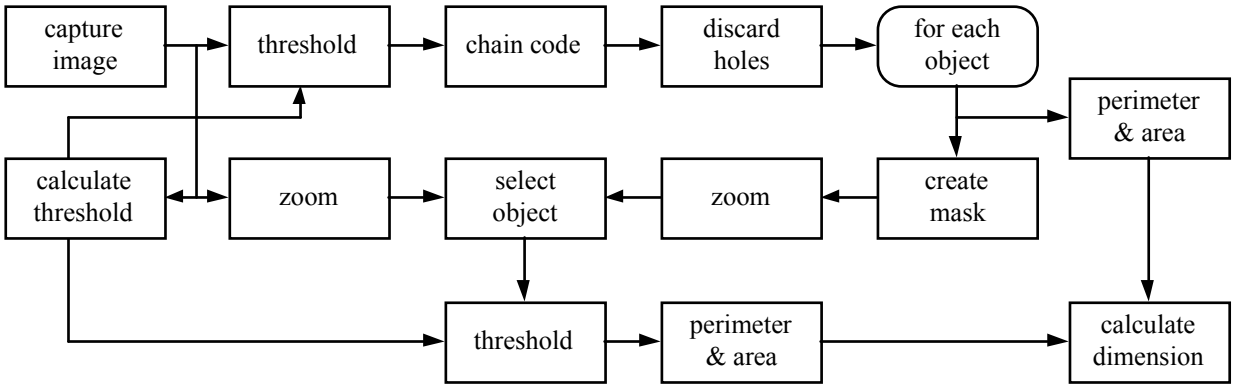
This project was commissioned by researchers in the Department of Physiology and Anatomy, the Department of Veterinary Clinical Sciences and the Department of Physics and Biophyisics.

SHAPE ANALYSIS OF CASEIN PARTICLES

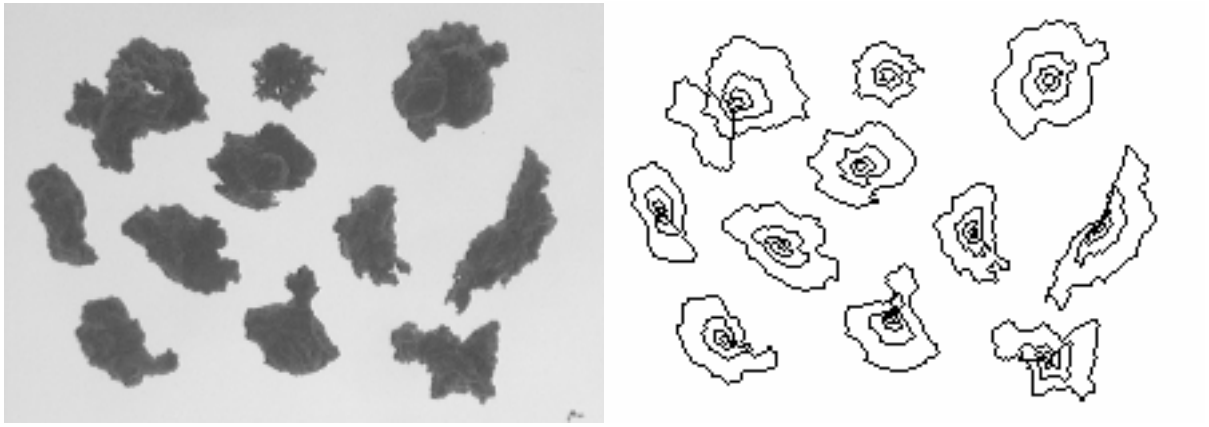
An important characteristic of casein particles is the surface roughness. Related to the surface topography is the shape of the silhouette, which is also easier to analyse. A useful shape feature that relates to roughness is the fractal dimension [5]. This work was performed for researchers in the Food Technology Department.

The fractal dimension of the perimeter is determined by measuring the perimeter of the particle over a range of scales or resolutions. By plotting the perimeter as a function of scale

on a log-log graph, the slope of the line corresponds to the fractal dimension. The rougher the boundary, the higher the measured dimension.



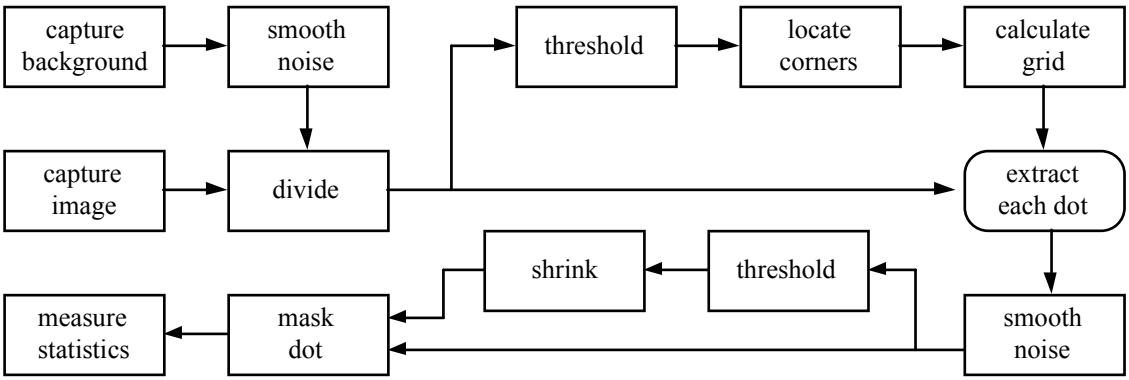
Algorithm used for shape analysis of casein particles



Original image (left); the series of perimeters at different scales (right)

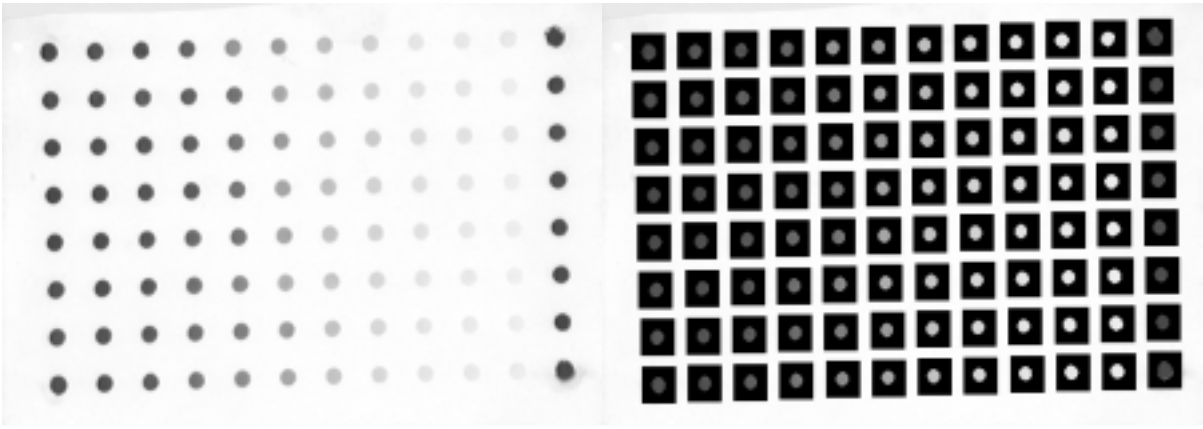
DOT BLOT DENSITY MEASUREMENT

One method of measuring the concentration of proteins in a sample is to use a dot blot technique. The protein-containing sample is diluted and deposited onto a membrane. The protein is then selectively developed (or dyed), giving a series of dots on the membrane. The density of each dot is compared with the density of a calibration sequence to determine the actual protein concentration. This technique was being investigated for use by the Dairy Research Institute.



Algorithm used for dot blot density measurement

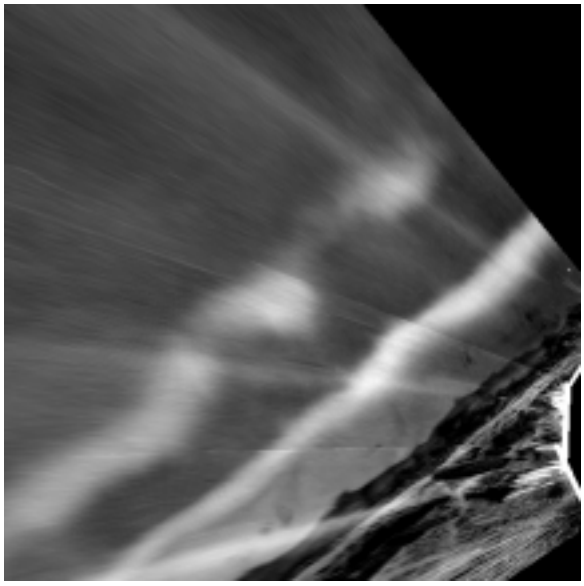
The captured image is normalised by dividing by a background image (captured without any membrane present). This compensates for any variations in lighting, particularly any gradient in lighting from one side of the image to the other. Each membrane holds a 12 by 8 array of dots, with the corner dots heavily stained. This enables the grid to be determined by locating the corner dots. This increases the flexibility of the positioning of the membrane and also enables very faint or unstained dots to be located. For each calculated dot position, the dot is detected and the average density within the dot is calculated. This density is compared to a calibration sequence to determine the protein concentration.



Calibration sequence for the milk protein Immunoglobulin G (left); after processing (right)

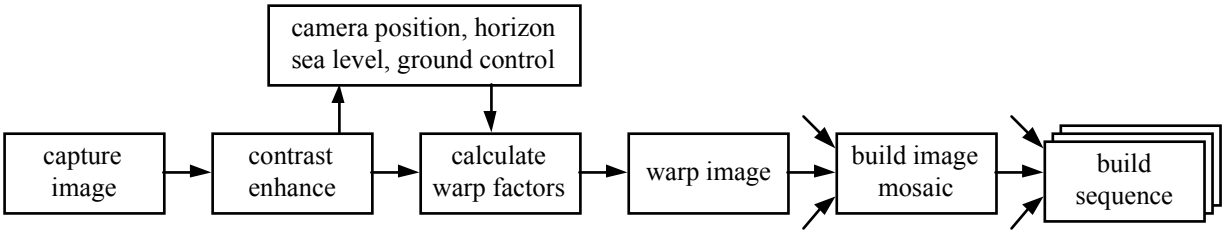
SAND BAR EVOLUTION

A researcher in the Geography Department was wanting to investigate the evolution of sand bars. The position and intensity of waves breaking are strongly related to the position and depth of any sand bars if present [5]. Time exposure (10 minutes) photographs taken from a cliff top overlooking a beach are corrected for perspective distortion and rectified to map coordinates. By combining several images looking in different directions, a large extent of the beach may be covered. By taking a series of such photographs, a time sequence is able to be constructed and the changes in sand bar morphology are able to be investigated.



Original scene (above); mosaic of 3 rectified scenes (right), representing a 512 m by 512 m region The above scene is the middle of the 3 panels.

Although such rectification techniques are used routinely in the processing of satellite images, here they are used to compensate quite severe distortions very effectively.



Algorithm used to compensate for perspective distortion in sand bar images

SUMMARY

Image analysis techniques can be of significant benefit to researchers in a wide range of disciplines, as is illustrated by the projects described here. It should also be emphasised that this is only a sample of the work performed by the Unit. Other recent projects include colour image segmentation; stereo range finding; image resolution improvement; DNA gel sequencing; measurement of kiwifruit ovaries; and cell counting.

REFERENCES

[1] Conway J.F., and Ngan P.M., "The Image Analysis Unit at Massey University", *3rd NZ Image Processing Workshop*, Palmerston North (1988)

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[5] Bhaskar G.V., Campanella O.H., and Munro P.A., "Fractal dimension of casein precipitate particles", accepted for presentation at *Chemica Conference*, Sydney, Australia (September 1992)

[6] Lippmann T.C. and Holman R.A., "Quantification of sand bar morphology: a video technique based on wave dissipation", *Journal of Geophysical Research*, vol 94, no C1, pp 995-1011 (1989)