# A PRELIMINARY EXPERIMENT OF THE OBSERVATION OF THE MANDIBLE BY MEANS OF COMPUTER CONTROLLED RADIOGRAPHY

H. Ito and S. Kiritani

By using the computer controlled radiographic technique,[1] automatic identification of the anterior outline of the mandible has been attempted.

Fig. 1 shows an x-ray image of the anterior part of the mandible which was obtained by an overall scanning of a rectangular field. Brightness of each display point represents the magnitude of x-ray attenuation* at the sam-

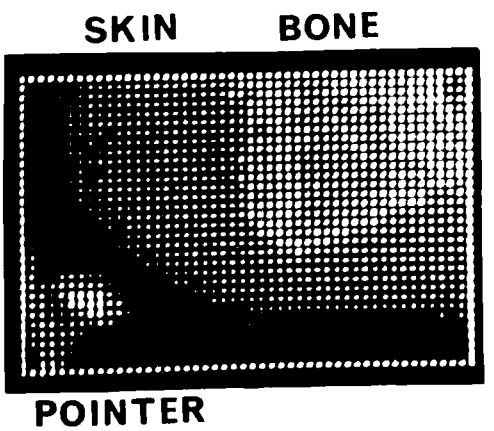


Fig. 1. An example of the x-ray image of the anterior part of the mandible obtained by an overall scanning of a rectangular field.

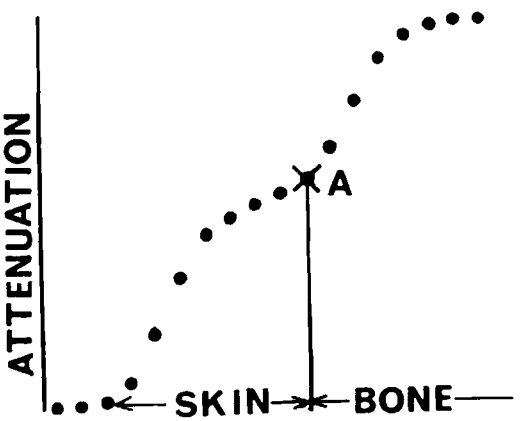


Fig. 2. Typical pattern of the spatial variation in the x-ray attenuation along a linear scan line approximately perpendicular to the bone outline (schematic).

---

* In the present computer program, the value $-K \cdot \log \frac{I}{I_0}$ is used as the measure of the x-ray intensity at each sample point. "I" is the x-ray intensity transmitted through the object, "$I_0$" the x-ray intensity measured without object and "K" a positive constant.

pled position. The distance between consecutive sample points was approximately 1 mm in the object plane and the exposure time for each sample point was 1 msec. Fig. 2 schematically shows a typical curve representing the spatial variation of the x-ray attenuation along a scan line which is approximately perpendicular to the surface of the bone. X-ray attenuation first rapidly increases when scanning goes from the object free area into the skin and then gradually levels off. After this point, the x-ray attenuation shows a rapid increase again as the scanning passes through the bone outline. Thus, in Fig. 2, the point A can be taken as situated on the outline of the bone. On the given series of measured radiopacity values along the scan line, a point was determined to be at this skin-bone boundary where the curvature of the spatial variations in the x-ray intensity was locally maximum. The 'curvature' value was defined in terms of the second-order difference by using intensity values at 8 contiguous points on the scan line centering around each sampled point. As additional conditions for the boundary point, we adopted: the curvature value must be larger than a predetermined threshold value, and the x-ray intensity at that point must lie within a certain range. The latter condition was to avoid erroneously identifying the air-skin boundary or some points within the bone. The process of determing the entire outline of the mandible bone was as follows (Fig. 3). First, starting from a

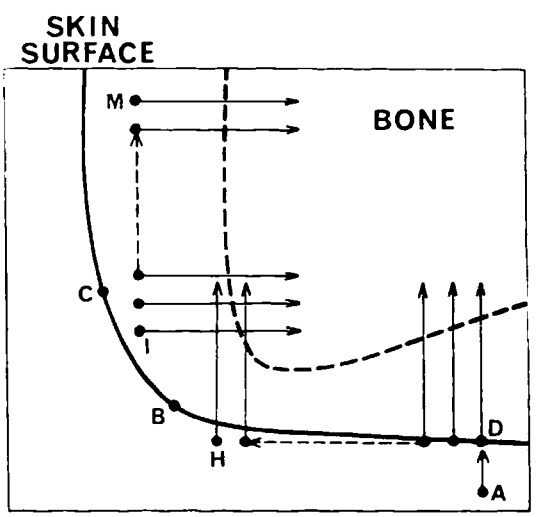


Fig. 3. Scanning process for identifying the outline of the mandible.

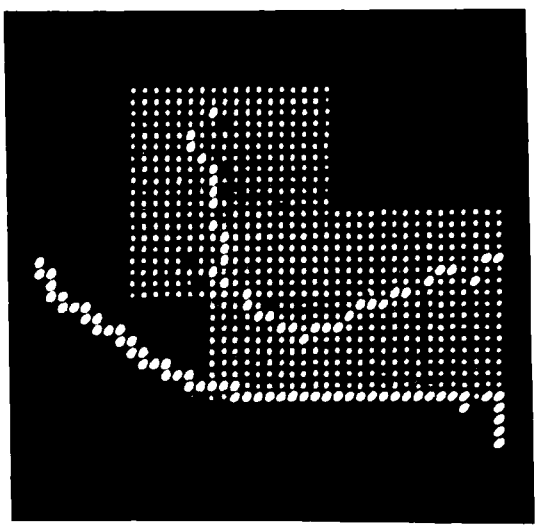

Fig. 4. Outline of the anterior part of the mandible determined for the x-ray image in Fig. 1.

point in the object-free area in the lower right corner of the image field, a linear scan was made upward until the surface of the skin was detected. Then, the skin surface was traced towards left until an upward turn of the surface line representing the tip of the jaw was found. When it was found during this process that the positioning of the jaw in the field was not appropriate, the exposure was stopped and the positioning was readjusted.

Next, vertical line scannings were made to identify the inferior margin of the mandible. The upper ends of the scan lines were automatically determined according to the detected position of the lower surface of the jaw. The rightmost scan line was located at an appropriate distance from the tip of the jaw to the right, and the scanning was shifted from right to left. On each scan line, a point on the bone outline was determined as described above.

Near the frontal surface of the jaw, scanning does not cross the bone outline and the x-ray attenuation is approximately constant except for the first rapid increase at the skin surface. On such scan lines, the computed curvature value was found constantly negative. When such an intensity curve was observed for some successive scan lines, the vertical scan mode was switched to a similar horizontal scan for tracing the frontal outline of the mandible.

Fig. 4 shows the outline of the mandible bone determined by this method, using the overall scanned data of Fig. 1. The outline of the skin surface is also shown for reference. All the sample points to be examined for this boundary determination are indicated by thinner dots. As can be seen from this example, a sufficiently well defined bone outline can be obtained by using an exposure time of 1 msec per sample point.

In order to see the minimum necessary exposure for determining the position of the mandible, the method described above was tested for the x-ray image data with lower exposures (exposure time of 250, 125, 65 microsec per sample point). For these data, we exposed only a relatively narrow area, which was determined automatically according to the real time tracing of the skin surface. Examples of the obtained x-ray images and the detected outlines of the mandible are shown in Fig. 5.

It appears that, for the present subject, the exposure time of 250 microsec per sample point was sufficient for the effective observation of the bone outline. With the exposure time of 125 microsec, some of the points were

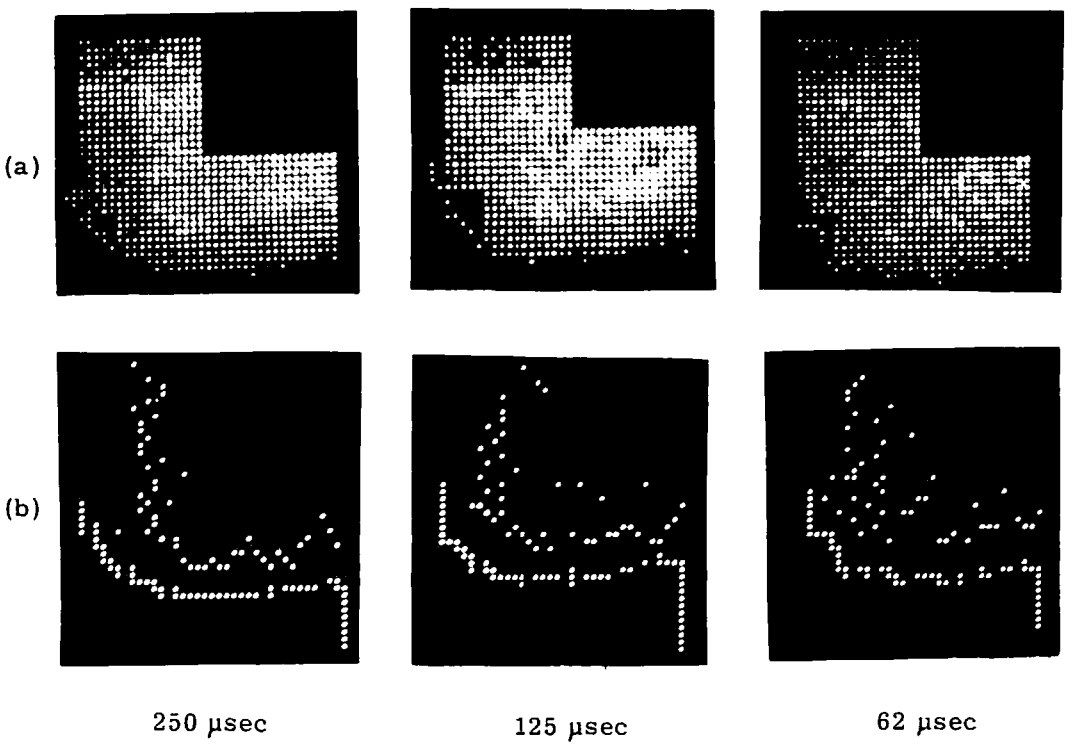


Fig. 5 (a) X-ray images obtained with shorter exposure times (250, 125, 62 μsec per sample point). Exposure was given only to a narrow area selected with reference to the observed position of the jaw surface.

(b) Outline of the mandible determined for the three x-ray images in (a).

quite discontinuously deviated from other points in the trace. However, it would be possible to exclude these points in determining the bone outline by using some kind of continuity criteria. With the 62-microsec exposure, the obtained trace was irregular and the observation of the bone outline was found impractical.

## References

1) O. Fujimura, S. Kiritani, and H. Ishida, "Digitally Controlled Dynamic Radiography, " Annual Bulletin (Research Institute of Logopedics and Phoniatrics, University of Tokyo) No. 3, 1-34 (1969).