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# Panoramic ultrasonic imaging

Final Report by

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# 1 Introduction

The ultrasound transducer consists of one-dimensional array piezoelectric elements which are excited in a time-delayed manner to form a spherical, focused wave. The aperture of the array antenna is usually limited by the number of system channels and the size of the elements. As a result of the limited aperture only a limited view can be obtained with a fixed transducer position. However, in many applications it is desirable to get a more comprehensive overview of the region of investigation. This problem can be overcome by recovering in-plane transducer motions and combining the information into a single panoramic image.

For example, ultrasonic longitudinal panoramic field of view shows a 6.38 cm pilonidal cyst.

Program module in Matlab [1] was developed for ultrasonic image stitching.

## 2 Main steps of ultrasonic image stitching

All computing can be divided into several steps. At first for registrations of the motions between images feature based methods are used, because it demands the least computational burden. Then initial matching from features can be done. Next, those matching points are used to create pair homography with RANSAC outlier removal [2]. RANSAC is an abbreviation for "RANDOM SAMPLE CONSENSUS". It is an iterative method to estimate parameters of a mathematical model from a set of observed data which contains outliers. After all pair homography is computed, so relationship between every pair of adjacent images is known. Then direct homography can be computed, which is used to transform images to the map, using first image as base line.

### 2.1 Feature finding

First of all the displacement of a small number of characteristic features, so-called landmarks, is computed. It based on the SIFT algorithm [3]. SIFT is abbreviation for "Scale-Invariant Feature Transform".

The key moment in feature detecting is building of Gaussian pyramid and Difference of Gaussian pyramid [4]. The scale space of an image is defined as a function

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y), \quad (2.1)$$

where  $L$  — value of Gaussian in a point with coordinates  $(x, y)$ ,  $\sigma$  — radius of blurring,  $G$  — Gaussian core,  $I$  — input image,  $*$  — convolution operation.

To efficiently detect stable keypoint locations in scale space, using scale-space extrema in the difference-of-Gaussian function convolved with the image was proposed.  $D(x, y, \sigma)$  can be computed from the difference of two nearby scales separated by a constant multiplicative factor  $k$ :

$$D(x, y, \sigma) = (G(x, y, k\sigma) - G(x, y, \sigma)) * I(x, y) = L(x, y, k\sigma) - L(x, y, \sigma) \quad (2.2)$$

Red markers denote the features on the both images.

Because of the SIFT-inspired object recognition approach to panorama stitching, the resulting system is insensitive to the ordering, orientation, scale and illumination of the images.

### 2.2 Image matching

On the following step the SIFT features extracted from the input images are matched against each other to find nearest-neighbor for each feature. Connections between features are denoted by blue lines. Because of fully automatic calculations there are some mistakes in feature matching. This problem can be solved by using RANSAC algorithm. It remove mistaken comparisons. We can compare matches before and after RANSAC. 28 initial matches were found, after RANSAC 26 matches were found. It means that 2 false matches were removed by RANSAC method.

## 2.3 Image transformation

Homography of the first image is assigned by matrix  $H1\_0 = [1 \ 0 \ 0; 0 \ 1 \ 0; 0 \ 0 \ 1]$ . Image1 is transformed to the map using  $H1\_0$  which is just identity 3-by-3 matrix, and image 0 means the map. Image2 is transformed by  $H2\_1$  to align with image1 and by  $H1\_0$  to be placed to the map. Homography between Image1 and Image2 is assigned by matrix

$$H2 = H1\_0 * H2\_1 \quad (2.3)$$

In the general case, every individual image will have its own Homography to the map, which will denote by  $H$  with serial number of image.

### 3 PSNR based image quality estimation

Final step is PSNR based image quality estimation [5]. PSNR is abbreviation for peak signal-to-noise ratio. It is used to measure the difference between two images. The first image is original modeling ultrasonic image and the second one is final panoramic image, which was stitching by Matlab. PSNR is defined by expression:

$$PSNR = 20 * \log_{10} \left( \frac{1}{rms} \right) \quad (3.1)$$

for grayscale images, where rms is the root mean square difference between two images. The PSNR is given in decibel units (dB), which measure the ratio of the peak signal and the difference between two images. An increase of 20 dB corresponds to a ten-fold decrease in the rms difference between two images.

There are many versions of signal-to-noise ratios, but the PSNR is very common in image processing, probably because it gives better-sounding numbers than other measures.

For these two images PSNR possess the value 44.46dB. It means that the stitching is of high quality.

## **4 Conclusion**

The developed program module in Matlab makes it possible to stitch ultrasonic images into the panoramic image. It has good runtime performance and stability. In this work panoramic images were generated from two and several ultrasonic images received by linear array. The final panoramic image is of high quality. And at present, modeling data for phased array are obtained.

## 5 Bibliography

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