Signal and Image Processing in the Center of Cuba: Center for Studies on Electronics and Information Technologies (CEETI)

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ABSTRACT
A brief description of CEETI is given, addressing its history, research lines, main scientific results and current projects.

Keywords
Image Processing, Signal Processing, Cuba.

1. INTRODUCTION
The Center for Studies in Electronics and Information Technologies (CEETI) was founded in 1996 with the purpose of developing research projects in the fields of digital image and signal processing (DIP and DSP, respectively). Research activity at CEETI has led to various results, published in refereed scientific journals, a selection of which follows.

2. IMAGE PROCESSING AT CEETI
DIP at CEETI has been performed in response to both practical and theoretical problems. The main areas addressed are shown and commented below.

Factors affecting image diagnostic value.
The influence of radiologic dosage on image quality was addressed in [Per02] [Per03]. The reduction of the dosage while maintaining image diagnostic value is highly desirable to preserve patient's health. Expert's opinions together with ROC analysis were used to establish lower dosage limits without reaching a knee-like point in the ROC curve.

The effects of compression on image quality was the topic of [Paz09] in radiologic images, and of [Fal10] for leukocyte images. Lossy compression *codecs* like JPEG 2000, included in DICOM standard, introduce increasing image distortions as compression rates (CR) gets higher. The effect on a given image depends on its characteristics (color, contrast, noise levels, etc.). For this reason each image type is affected in a different way, and compression limits must be determined on a per-type basis. Fig. 1 illustrates the effect of compression in leukocyte images, as described in [Fal10].

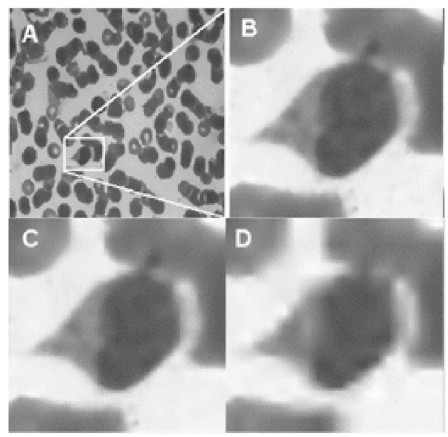

Figure 1: Effect of JPEG 2000 compression on leukocyte images. A: Original 1536H*2048W image. B, C and D: details of a monocyte with CR of 50:1, 100:1, and 200:1, respectively.

Again, expert's opinions and ROC curves were used, this time to determine CR limits.

Anomaly detection
The complex problem of anomaly detection in images was the content of [Tab09], and an application to cervical cancer detection was described in [Oro13].

In the latter work [Oro13], a preprocessing of the image is performed, based on the saliency concept from biological vision systems. Smear images show a high variability in content, as shown in Fig. 2. A new method for identifying salient regions in pap smear images is proposed and compared to previously reported approaches.

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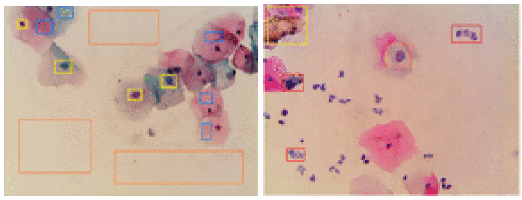

Figure 2: Left, illustration of background (orange rectangles), cytoplasm (blue) and nuclei (yellow) in Papanicolau test images. Right, difficulties found: touching cells (yellow rectangle) and noise (red rectangles).

How such machine-saliency methods can be used to improve human performance in a realistic anomaly detection task is also described.

Noise reduction in phase images

Noise filtering of phase images was addressed in [Lor02] [Lor07] [Cru09]. An advanced application is reported in [Car02] using quantum-dot cellular automata. Phase images appear in several applications, like magnetic resonance images (MRI) or interferometric synthetic aperture radar (IFSAR).

Phase unwrapping in 2D is not uniquely defined, and noise greatly affects its estimation. In [Lor02] several methods and models were proposed and evaluated in terms of the quality of the reconstructed unwrapped phase. In Fig. 3 an example of the results obtained for the best denoising method is shown, for a spherical phantom.

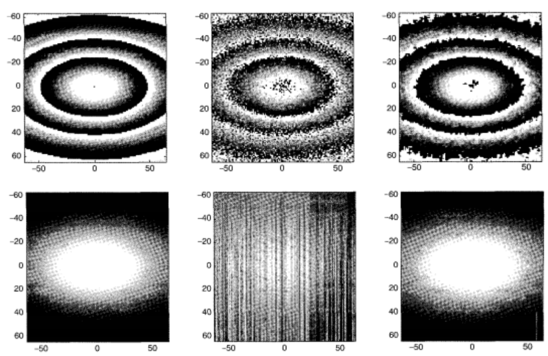

Figure 3 Wraped (top) and unwrapped (bottom) phase images of a spherical phantom. Left: original, center: noisy, right: filtered.

Later, other denoising techniques were evaluated (e.g. wavelets in [Cru09]).

Cellular Microscopy

Research on DIP of cellular microscopy images has led to results reported in various papers, among them in [Oro11] [Lor13] and [Coc14].

In [Oro11], the segmentation of cell nuclei and cytoplasm is required, since the ratio between both areas in a cell is an important feature for cancer diagnosis. Cell nuclei in Papanicolau tests are highly variable in terms of shape and texture, as shown in Fig. 4.

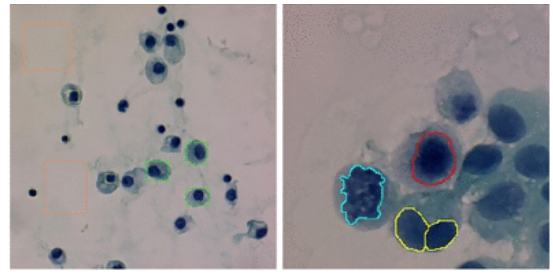

Figure 4: Left, illustration of background, cytoplasm and nuclei in Papanicolau test images. Right: nuclei variability (cyan, red and yellow).

This work used a two phase approach for nuclei segmentation, validated against manually segmented images and compared to several state-of-the-art methods.

3. OTHER RELEVANT RESULTS

Through its history, CEETI has also reached visibility in research areas other than DIP.

Compression, filtering and classification of ECG signals was the main topic in CEETI's early years [Mor97] [Car98] [Tab99]. EEG signals have also been addressed, either for its compression [Car04] [Baz12a] [Baz12b] or analysis [Rui09] [Rui10] [Rui12].

Speech processing has been an active area of research at CEETI, where most significant results are associated to the measurement of perturbations in pathological speech [Fer05] [Fer09] [Fer10].

Some results have also been obtained in the processing of genomic sequences [Fue07] [Lor09].

General-purpose DSP algorithms and techniques have also been addressed, like noise reduction using wavelets [Can02] or bionic models in classification tasks [Gon10].

4. CURRENT PROJECTS

The line of DIP at CEETI is currently centered in two main topics, one in the detection of anomalies in cell microscopy, and other in neuronal (and arteries/veins) tracing methods. Biomedical applications are still a priority at CEETI.

As for other research topics outside DIP (i.e. DSP), pathological speech processing is the strongest line. The usefulness of speech to diagnose a pathology or reflect its severity is being studied on dysphonias, cognitive impairing diseases and sleep apnea, among others.

5. ACKNOWLEDGMENTS

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