

## Komputerowe wsparcie diagnostyki dla biopsji optycznej z wykorzystaniem analizy obrazów fotodynamicznych

### Computer Aided Diagnosis for Optical Biopsy Using Photodynamic Images Analysis

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#### Abstract

The biopsy is the main criteria for cancer diagnosis, especially in early histopathological stage. Proper choice of tissue acquisition is the critical issue for success of such examination.

In this study the CAD software is presented. It is based on photodynamical images analysis. These images were acquired during endoscopic examination of the patients, with use of Xillix Onco LIFE optical system. Photodynamical images utilize phenomena of fluorescence of the tissue, which differs for healthy and the pathological one.

The Numerical Color Value NCV (See formula 1.) allows us to distinguish normal from cancerous tissue. Values of NCV for pathological tissue are presented in Table 1.

The aim of presented software is to support work of physician during and after examination.

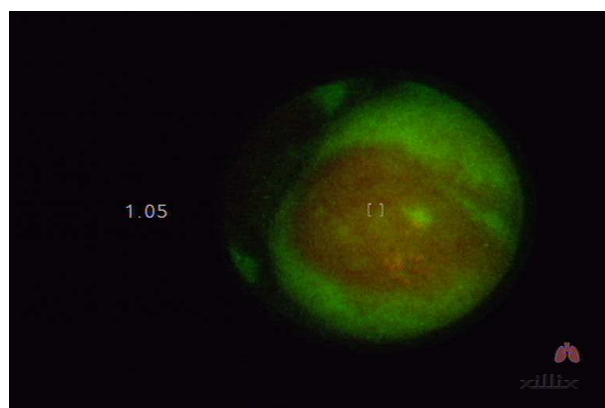
#### 1. Purpose

The early, and accurate detection of cancer diseases or the precancerous states is most important, when concerning further patient treatment. Most of such diseases can be cured if only are detected soon enough - in the early histopathological stage.

The analysis of photodynamical images is a part of fluorescence diagnostics. This method is based on the tissue fluorescence phenomena, and utilize endoscopic examination of the patient (i. e. bronchoscopy or colonoscopy). Fluorescence of the tissue is induced by the photosensitizer (delta aminolevulinic acid). This substance is selectively absorbed in cancer tissue. The light emitted from the tumor and healthy tissue differ significantly.[1]

In the study, during the tissue examination the Laser Induced Fluorescence (LIFE) phenomena is used. The fluorescence of the tissue is excited by broad-band blue light. The part of falling light which is not reflected, is dispersed and absorbed by the tissue. The energy absorbed in the tissue is then

reemitted as fluorescence. The fluorescence is captured and analyzed by the optical system. Example of such system is the Xillix Onco LIFE system consisting of two complementary (CCD and Spectral) cameras. These cameras are connected to an endoscopic optical system. The Xillix camera system takes two pictures: one of green autofluorescence and a second of red dispersed reflection. The picture of the pathological tissue in red dispersed reflection resembles healthy tissue while the green autofluorescence picture decreases significantly for the tumor. When there is one combined image built of reflected and fluorescence image, the color difference shows the pathological region. The combined image is called the photodynamical image and it is base for the optical analysis of histopathological state. Additionally, the spectral analysis is introduced for greater sensitivity and increased precision in description of the



character of the changes in the tissue. [1]

**Rys.1. Fotodynamiczny obraz tkanki języka**

**Fig.1. Photodynamical image of the tissue of the tongue**

In the standard Xillix Onco LIFE system image can be analyzed in various ways in order to obtain final results. The analysis, however, can be performed in one point of the image only. In the paper a new software dedicated to analysis of the photodynamical images is presented. The analysis is performed in a following steps: image acquisition

and initial processing, background removal, and region of interest (pathological tissue) determination.

## 2. Methodology

### 2.1 Introduction

During the computerized image analysis, in order to distinguish healthy tissue from the pathological one the quantitative description of each image pixel is needed. The Numerical Color Value (NCV) is thus defined for each picture pixel as a ratio of red to green components of its color [2] (basically the ratio of reflected light and fluorescence).

$$NCV = \frac{R}{G} \quad (1)$$

As the green component (autofluorescence) decreases in points of image corresponding to cancerous tissue, the higher values of NCV coefficient are expected for the pathological parts of the investigated region [1] (See Table 1).

Tab.1.

**Średnie wartości NCV dla różnych schorzeń**  
**Average NCV values for different types of diseases <sup>1</sup>**

Type of disease	Avg NCV
Bronchus dysplasia	1,1 – 1,4
Oral leukoplakia with dysplasia	1,2 – 1,5
Oral leukoplakia without dysplasia	1,0 – 1,2
Tongue cancer	1,6 – 2,5
Vocal fold cancer	1,6 – 2,5
Bowen's illness	0,8 – 1,2
Basal cell carcinoma	1,4 – 3,0
Bronchus cancer	1,8 – 2,5
Bronchitis	0,5 – 1,0
Bronchial epithelium metaplasia	1,0 – 1,3

### 2.2 CAD software

In order to support physician, during and after examination of the patient, the CAD software is being developed. As in early stages of cancerous diseases changes in the tissue are relatively small and may be overlooked or misjudged as a healthy regions, software capable of automated, parallel analysis of the whole image might reduce danger of incorrect diagnosis.

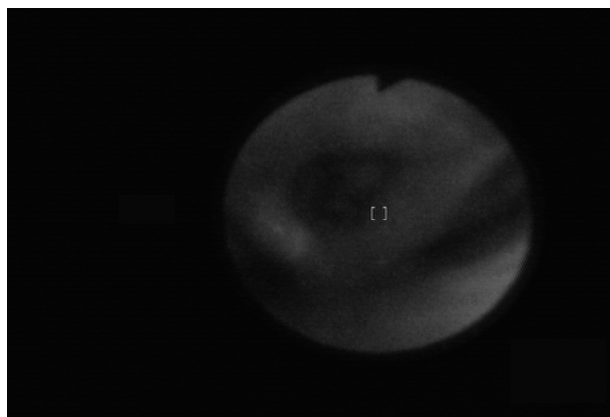
<sup>1</sup> Research still in progress, [1, 2]

Such software has been created, using .NET framework environment, and written in C# language. The choice of platform permits higher coverage.

Following stages of photodynamical images processing are implemented in the application:

#### 2.1.1 Loading images and the initial processing

This stage consists of transferring image data into memory, calculation of the NCV value for each pixel and creation of image grayscale representation, according to formula:



$$Y = 0,3R + 0,59G + 0,11B \quad (2)$$

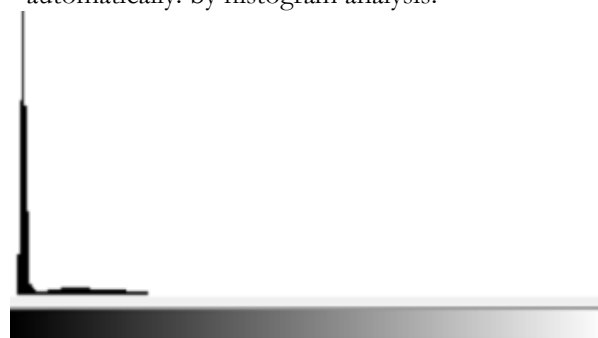
Rys.2. Monochromatyczna reprezentacja obrazu fotodynamicznego

Fig.2. Grayscale representation of photodynamical image

#### 2.2.2 Background removal

Once the image data is loaded, the background elements need to be removed. because of high NCV values for background pixels (higher than for diagnostically-relevant pixels), the segmentation of the background can be done using thresholding . In CAD application, the threshold can be selected manually, semiautomatically or automatically:

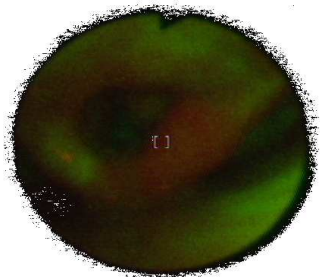
- manually: by user who enters any value from range 0-255
- semiautomatically: by user, who simply clicks any pixel in the image. The grayscale value of that pixel is used as a threshold
- automatically: by histogram analysis.



Rys.3. Histogram monochromatycznej reprezentacji obrazu fotodynamicznego

Fig.3. Histogram of grayscale representation of photodynamical image

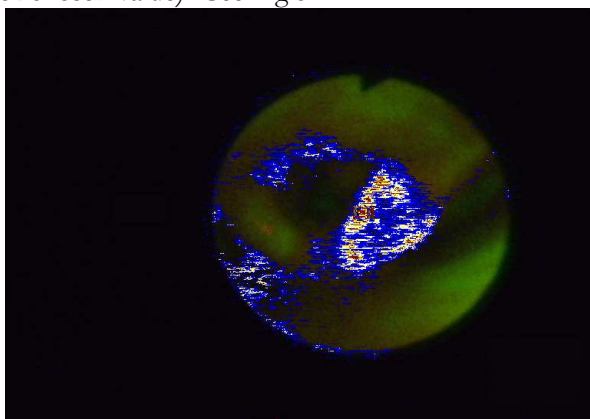
The highest peak on the histogram corresponds to almost all background pixels. The threshold value is selected as a last (to the right) gray level for which quantity of pixels exceeds average quantity multiplied by N. The N denotes the expected ratio of background and diagnostic pixels.



**Rys.4. Obraz fotodynamiczny po usunięciu tła**  
**Fig.4. Photodynamical image with removed background**

### 2.2.3 ROI determination

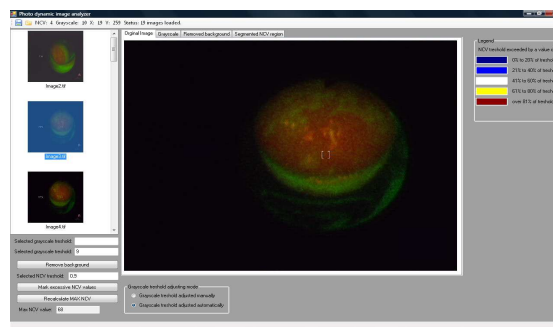
As the diagnosis depend on the NCV observed in the photodynamic pictures, in the next step the desire value of that coefficient needs to be specified. This can be done using a predefined dictionary (cf. Table 1) or by manually entering examined value. Once the NCV value is selected, all pixels for which this value is exceeded are marked on the image, with five different colors. Each color corresponds with one of five different levels (i. e. yellow region stands for pixels with NCV value from 160% up to 180% of chosen value). See Fig 5.



**Rys.5. Obraz fotodynamiczny z zaznaczonym mapowaniem NCV**  
**Fig.5. Photodynamical image with NCV mapping**

## 3. Results

The CAD application has been equipped in user-friendly interface, which enables observing and control of each processing stage. User is able to investigate all values (RGB, grayscale, NCV) of each pixel of analyzed image. It also provides possibility of saving any result obtained during work into a to file.



**Rys.6. Okno aplikacji**  
**Fig.6. Application window**

During the initial test, the application has been tested using fourteen clinical cases (fifty images). For each patient a classical biopsy results have been available and and precise diagnosis has been known. Two normal cases have been included in the set.

During tests, each image has been processed and the ROI has been segmented using predefined values of NCV presented in Tab. 1. In most cases segmented region, marked on the image has corresponded to the region of pathological changes in the tissue (shades of red color).

Manual adjustment of the NCV threshold has resulted in segmented region growing (when lowering the threshold), or shrinking (while decreasing the threshold). In this way more advanced pathological changes have been examined

For non-pathological cases none of the pixels data have been pointed as a disease-positive for any of predefined NCV.

## 4. Conclusions and future work

Developed CAD application permits detailed analysis of photodynamical images in the cancer diagnosis. By permitting parallel examination of all image pixels against know symptoms of various cancerous (and other) diseases, it shortens analysis time and increases the robustness of the process.

The usability of application in its current state, unfortunately, is limited by the lack of direct connection between Xillix Onco LIFE system and the CAD. The necessity of managing the additional file-system-based image database decreases the comfort of the work. The method of direct acquisition needs thus to be designed in order to speed diagnosis.

In this form application is a good tool for results verification of the endoscopic examination of the patient. Small changes may be overlooked by physician, and this application can detect and mark them. Tissue samples taken for the histopathological examination can be taken only from limited places so optical analysis of the whole investigated region may be good source of information, complementary to results obtained in the traditional way.

## Bibliography

[1]. Sebastian Kwiatek, Aleksandra Kawczyk-Krupka, Wojciech Latos, Ewa Synakiewicz, Dorota Stołtny, Anna Kosciarz-Grzesiok, Grzegorz Cieślak, Aleksander Sieroń, Fluorescent spectroscopy in diagnosis of basal cell carcinoma of skin and leukoplakia of oral cavity

[2] A. Sieroń, P. Gibiński, T. Pustelny, S. Kwiatek, Z. Opilski, A. Krawczyk-Krupka, T. Woźnica, E. Maciak, W. Kubica, M. Urbańczyk, W. Latos Optical biopsy using spectral camera in BBC and oral leukoplakia.

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