ARTIFICIAL INTELLIGENCE METHODS FOR DIAGNOSIS OF EARLY GASTRIC CANCER WITH MAGNIFYING NARROW BAND IMAGING ENDOSCOPY

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BACKGROUND. Magnifying narrow-band imaging (M-NBI) endoscopy significantly improves the diagnostic accuracy of gastric epithelial neoplastic lesions. However, effective application of M-NBI endoscopy is difficult due to the presence of various changes of gastric mucosal patterns, and therefore requires appropriate training. Computer-aided decision support systems based on endoscopic image analysis are being designed to assist an endoscopist in enhancing the diagnosis and mastering advanced techniques that require a high level of expertise. Recently convolutional neural networks (CNN) have become one of the most popular and effective approaches in different fields of endoscopic image analysis.

AIMS AND METHODS. The aim of this study was to develop a system for automatic identification of gastric cancer on M-NBI images using deep learning through CNN.

Image database. The database of 1293 M-NBI endoscopic images was created (Fig. 1). It consisted of 357 M-NBI images of cancerous lesions and 936 M-NBI images of non-cancerous lesions (Olympus Exera II, GIF Q160Z, Lucera GIF, Q260Z, EXERA III, GIF HQ 190).

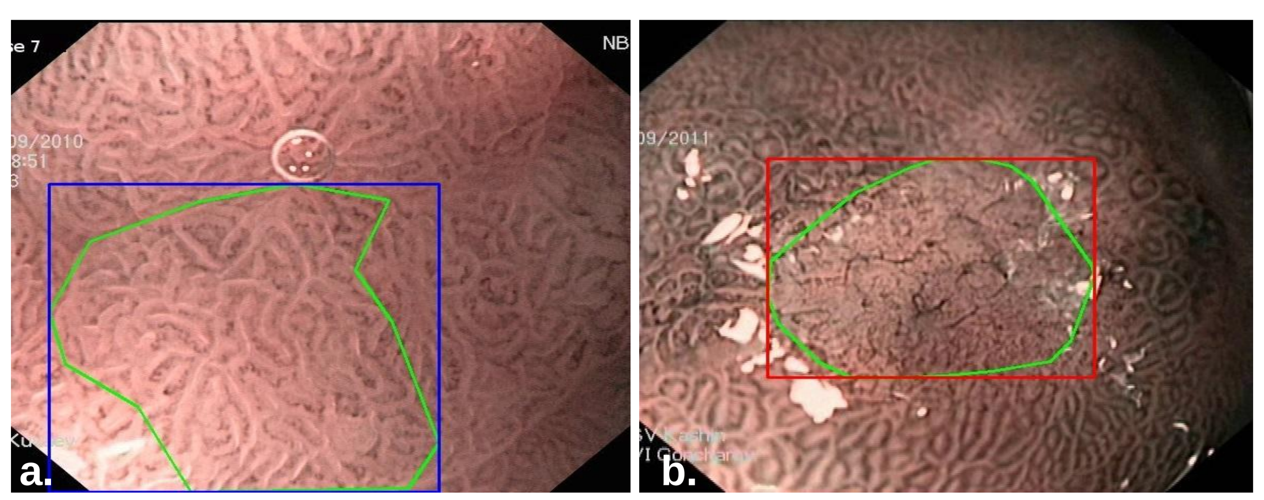
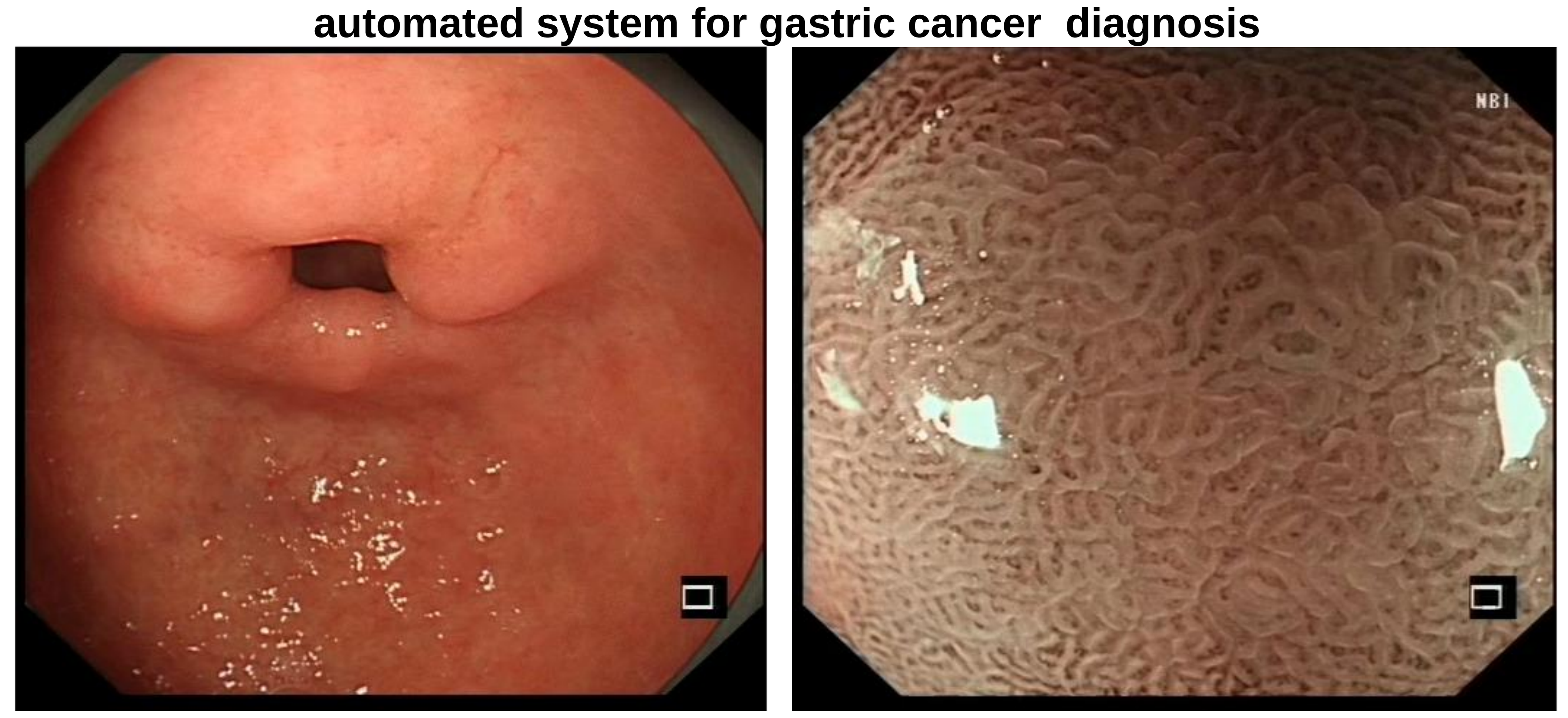


Fig. 1. Examples of database M-NBI images with areas of interest highlighted manually by the experts : a – non-cancerous lesion; b – early gastric cancer

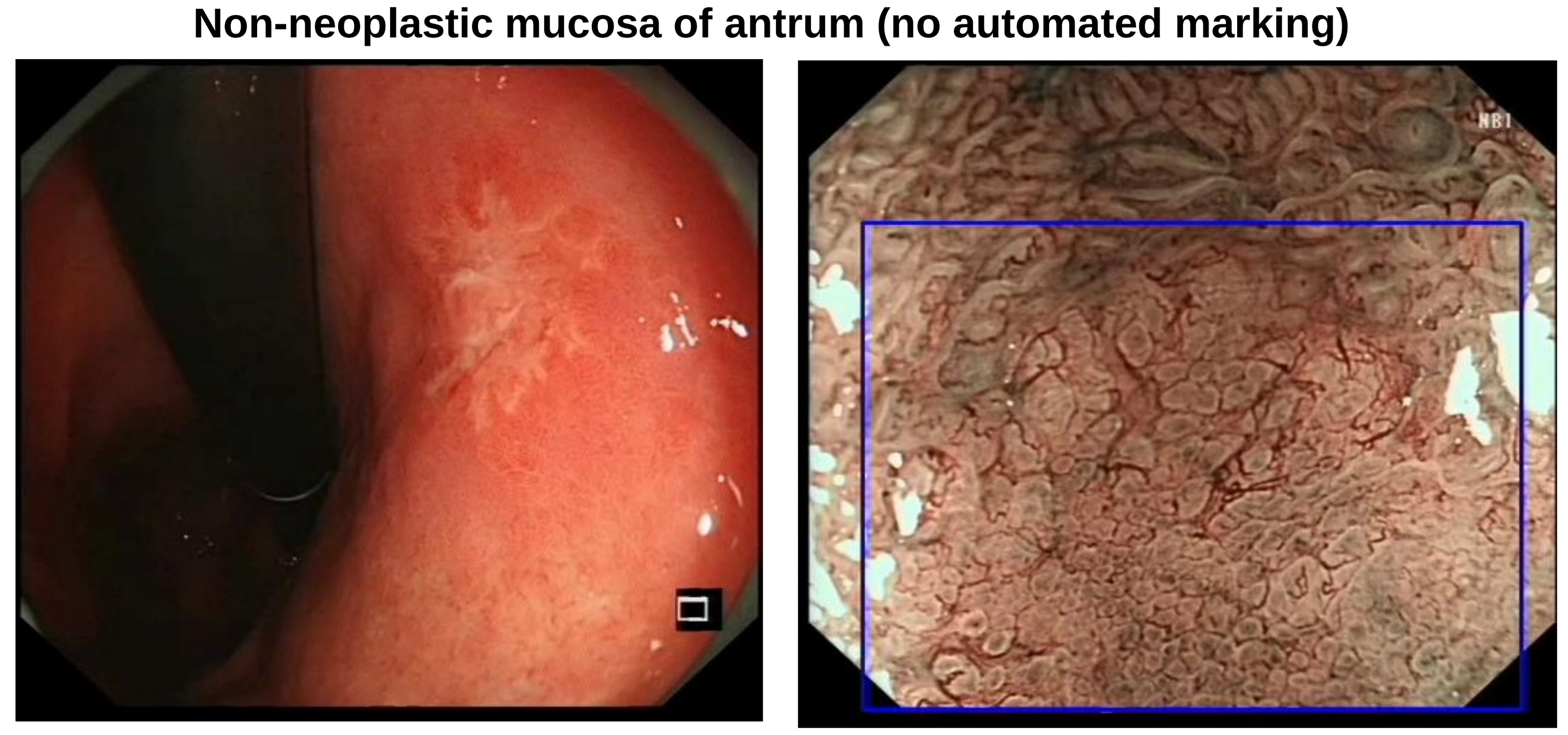
Image analysis algorithm. The developed image analysis algorithm was based on the application of the Single Shot Multibox Detector (SSD) architecture of CNN. The network architecture was implemented using the Caffe framework. The CNN was pre-trained on the ImageNet image database (http://www.image-net.org/) which was used to initialize part of the weights. The weights of the remaining layers were initialized using Xavier initialization. CNN training was done simultaneously with 8 GPU video cards of the NVIDIA DGX-1 supercomputer.

Testing and analysis. For numerical experiments 100 images were randomly selected from the endoscopic image database: 24 images of cancer and 76 images of non-cancerous lesions. The videodata of M-NBI endoscopic procedures (415 frames which were not presented in the database) was blindly analyzed by the designed system and an expert endoscopist to compare it with the doctor's diagnosis. Spatial correlation between automated results and experts opinion was assessed.

Fig. 2. Endoscopic images from video of M-NBI procedure with automated system for gastric cancer diagnosis



Non-neoplastic mucosa of antrum (no automated marking)



Early gastric cancer, type 0-IIc, lesser curvature of gastric body (automated marking with blue rectangular box)

RESULTS. Average precision for “cancer” class was 0,827, average precision for “non-cancer” class was 0,923, mean average precision was 0,875. Average intersect over union (IoU) score was 0,767 which corresponds to high concordance between automated and expert marking of gastric cancer areas (Fig.3-5).

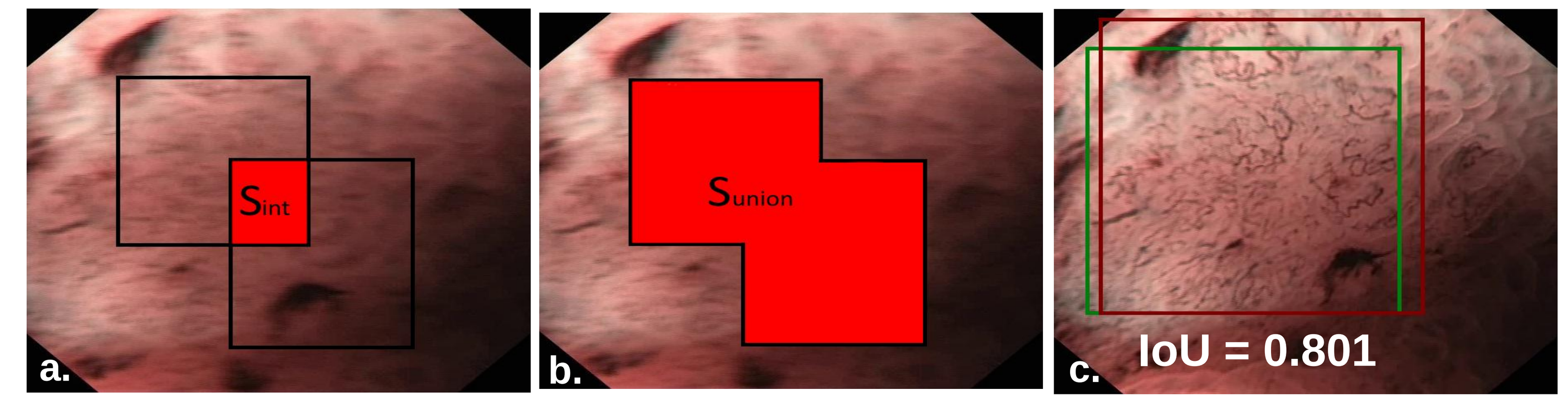


Fig. 3. Calculation IoU score: a. area of intersection of expert and algorithm bounding boxes; b. area of the union; c. example of cancer detection on video

$$IoU = \frac{S_{int}}{S_{union}}$$

Fig. 4. Histogram of the values of bounding boxes area marked by expert and algorithm

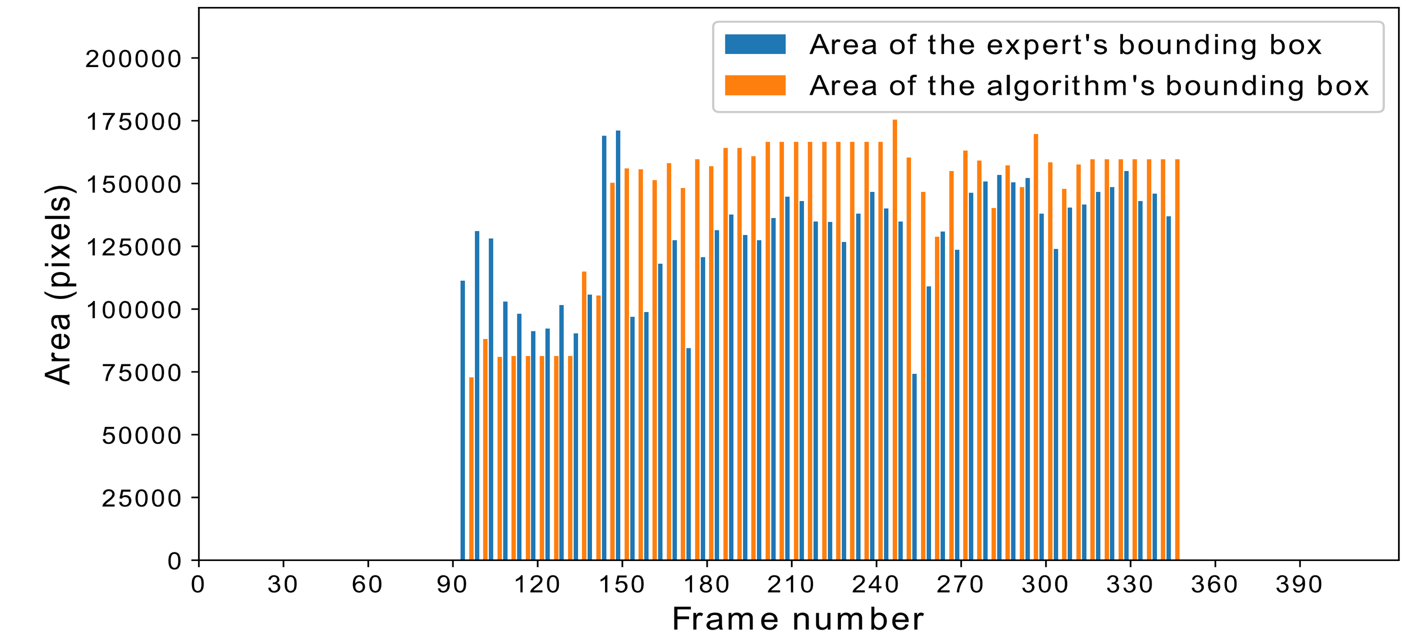
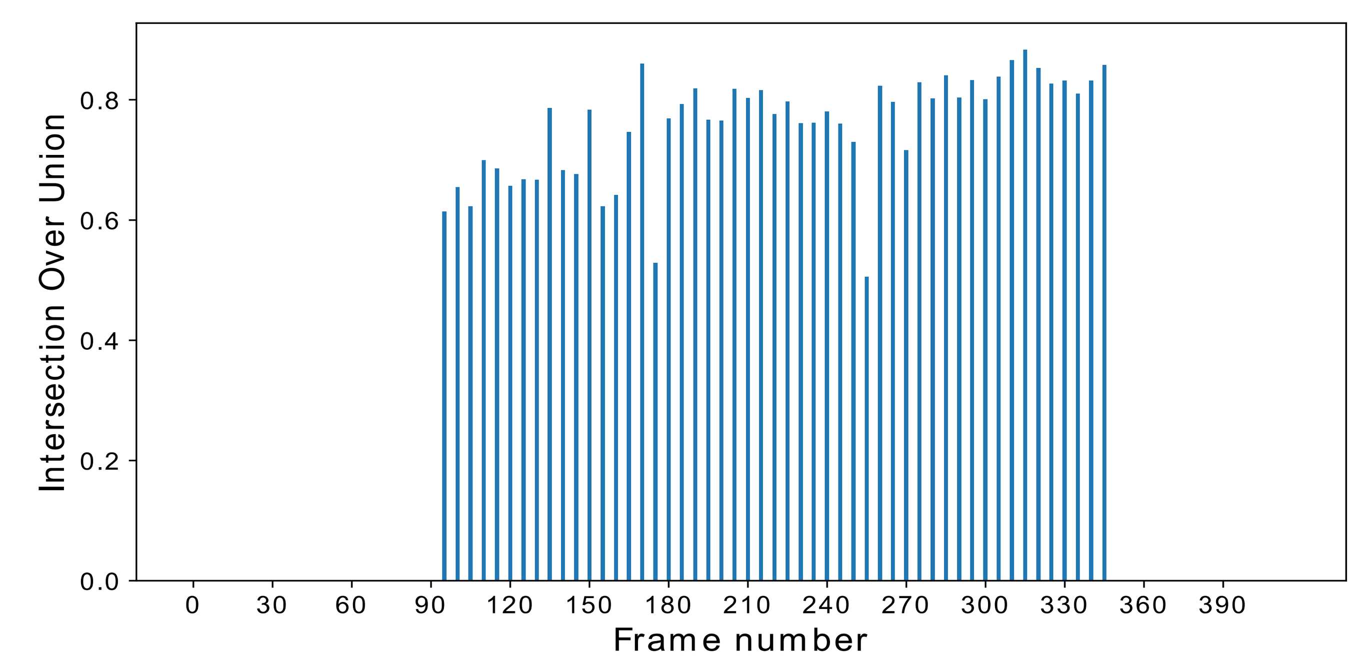


Fig. 5. Histogram of IoU metric values



CONCLUSION. The proposed algorithm of image analysis based on deep learning through SSD CNN allowed to design the automated system for NBI-M endoscopic diagnosis of gastric cancer. The designed system is able to analyze videodata (Fig. 2) and can be implemented in endoscopic electronic data collecting system for further testing in daily clinical practice.