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Computer Aided Diagnosis of Medical Images

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Abstract: *Medical images are obtained from various imaging modalities and diagnosis of pathological conditions from these images with the aid of computer is Computer aided diagnosis (CAD). After image acquisition, the image is initially subjected to preprocessing task, followed by segmentation and feature extraction, and finally classification for diagnosis of the pathological condition. The imaging modalities in consideration are X-ray radiographs, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasonography (USG) and Nuclear Imaging (PET/SPECT). Diagnosis of pathological conditions include lung cancer, breast cancer, colon cancer, Alzheimer's disease, spine cancer, aneurysm, interstitial lung disease, etc.*

Key Words: *Computer Aided Diagnosis (CAD), X-ray Radiography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasonography (USG), Mammography, Positron Emission Tomography (PET).*

I. Introduction

Medical surface/cross-sectional images are obtained from various imaging modalities presently available which can be Digital X-ray Radiography, Computed Tomography (CT), Ultrasound Imaging or Ultrasonography (USG), Magnetic Resonance Imaging (MRI), Nuclear Imaging (PET/SPECT), etc. Computer aided diagnosis is the diagnosis of pathological conditions which are interpreted from these digital images with the aid of computer. After image acquisition, the image is initially subjected to preprocessing task, followed by segmentation and feature extraction, and finally classification for diagnosis of the pathological condition. Therefore, the steps involved in Computer Aid Diagnosis (CAD) are as given in Fig 1.

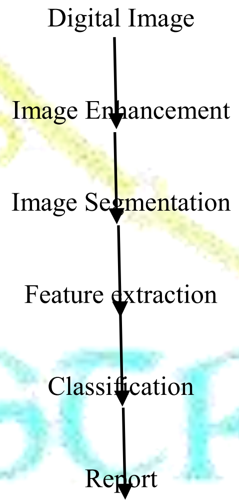

Fig 1: Computer Aided Diagnosis Process

The classification of CAD system can be Computer Aided Detection (CADe) and Computer Aided Diagnosis (CADx). As the name suggest, CADe systems are capable of detection or localization of the lesion or pathological features and CADx systems can make the diagnosis through classification of the extracted features.

Example of Computer Aided Diagnosis of Medical conditions include detection of masses on mammogram, analysis of chest digital X-ray radiographs, detecting lung modules in CT images, detection of polyps in colonoscopy, technique for breast MRI involving selection of region of interest, noise reduction, and classification to distinguish between malignant and benign breast lesions, multimodality framework based on neuro - fuzzy techniques to assess the task of myocardial viability using PET-MRI data fusion application, brain images for detection of brain tumor, liver studies in liver diseases, Image processing techniques on DNA, skin and hair, Embryo image processing to implant the embryo with the best chance of success by using image segmentation techniques.

Computer Aided Diagnosis from various imaging modalities

Earlier, automatic digital computer is used for diagnosis of a certain disorder from symptoms and physical findings of patient with relative probability using systematic statistical correlation technique. [(4)] The technique forms correlation constants between symptoms and disorders, and provided the most likely diagnosis for a new set of symptoms. Computers became increasingly used (along with diagnosis and decision making) for other applications like retrieval of patient records and medical literature, patient billing and record keeping, laboratory control system, Statistical data processing, etc. [(2)]. The use of a computer in medical image processing and diagnosis can reduce error, provide efficiency and economy, and quantitative measure of probability for diagnosis of medical conditions. A multicomponent computer aided medical decision and information system for emergency and critical care medicine called MEDAS had the capabilities of diagnosis using sequential Bayesian approach and treatment using a modular approach. [(1)]

There is a paradigm shift from evidence-based medicine to predictive models in personalized medicine [(6)] due to availability of increased information records e.g. health records, diagnostic tests, labs tests, imaging records, genomics, proteomics, treatments, etc. Personalized medicine is finding applications in prevention, diagnosis, treatment selection and monitoring of health conditions.

Computer Aided Diagnosis (CAD) system should have high detection sensitivity with low false positive (FP) rate. An early cancer detection CAD system using 3D computed tomography for colorectal polyp detection (colon cancer) and lung nodule detection (lung cancer) [(7)] have been implemented as two step classification. At first, sample pruning through parametric classification models (e.g. logistic regression, boosting, support/relevance vector machines are trained on the complexly distributed datasets as coarse, distributed-level classification to preserve the decision boundary in the high dimension feature space and discard the samples lying far from classification boundary. Then feature selection and graph embedding methods are jointly applied to find intrinsic lower dimensional feature subspace that preserves group-wise data topology. Final classification is done by nonparametric classifiers using kNN or template matching.

The optical scanning equipment and digital computers extended to clinical diagnostic radiology for Computer-Aided Diagnosis of radiographs. [(5)] Various efforts had already been done for developing automatic image analysis techniques for recognizing and classifying blood cells, chromosome analysis and karyotyping, identifying leucocytes, and processing scintigram images obtained in nuclear medicine. The most common radiograph is the conventional chest film which is used to ascertain lung disease, rheumatic heart disease, congenital and acquired heart disease, skeletal anomalies, and radiation-induced diseases. Four steps are involved for computer diagnosis of heart disease from the chest film.

(i) Digitization of the X-ray image. The resultant film of a conventional X-ray is a complex image costing of a two-dimensional projection of a three-dimensional object, whose structure reflects the absorption of X-rays as recorded on film. Such films commonly offer photographic resolution of 40-line pairs per millimeter. For digitization of X-ray image, a specialized camera scans the film which is illuminated from the ack, producing an output voltage whose average value is proportional to the amount of light transmitted through a point on the X-ray. Each such point is selected by the computer directly controlling the scanner camera. The optical image is converted point by point into a two-dimensional array of numbers, each of which represents the grey level of the image at a particular point.

(ii) Preprocess of the resultant digital X-ray image. This step is designed to enhance the extraction of selected features and to eliminate irrelevant data in an image. Gray level histograms are employed to determine if a distribution transformation should be employed. Spatial digital filtering methods utilizing the fast Fourier transform or recursive partial difference equations may be useful. Contrast enhancement is often employed, especially if the digital processed images are to be displayed. Image subtraction is often used to remove irrelevant image information.

(iii) Feature Extraction. Techniques which are useful in the feature extraction are directional signatures, contour tracing, Fourier transform frequency signatures, template matching, region enumeration techniques, and linguistic methods.

(iv) Classification. For classification, discrimination functions are used and for differential diagnosis, further division is done into subclasses of diseases.

X-ray images of the lungs are for diagnosis of pneumonia, [(17)] using deep learning by combination of image segmentation and feature fusion. After image segmentation to divide the lung area, Xception network is used to extract features which are passed to LSTM model for classification as pneumonia and no pneumonia. The accuracy obtained is 98% and the accuracy of AUC is 99%.

Image analysis system from contact endoscopy (CE) through morphometric analysis of segmented nuclei and fuzzy clustering classification approach have been used for Computer-Aided cancer diagnosis of larynx. (3) The classification results were verified by statistical analysis. Computer Aided Diagnosis is also used for automatic detection of diseases and anatomical landmarks in Gastrointestinal (GI) system from colonoscopy videos, (8) and also, for multi-class classification where labels are mined from corresponding text records using automatic text-chi strategy. (11) Gastroscopy images are also used in Computer Aided Diagnosis of gastric cancer using deep learning. (16) Multimedia system (12) is also developed for automatic analysis of video from Gastrointestinal (GI) endoscopy.

CAD system developed through artificial neural network (ANN) have been analysed using mammography, thoracic and colonic Computed Tomography (CT). (9) Computer aided diagnosis for detection of cancer region in CT images through image registration and CNN are also developed. (14) CT images with annotation lung modules are used in Computer Aided Diagnosis of lung cancer. (15)

Performance of CAD systems, based upon images obtained through Magnetic Resonance Imaging (MRI), X-ray, Mammography, and Ultrasound, is evaluated upon by precision, recall, specificity, accuracy and Mathews correlation co-efficient (MCC). Difference in each measure is accessed by paired t-tests.

Conclusion

Diagnosis of medical images through Computer Aided Diagnosis could be done with high sensitivity and accuracy with less false positive (FP) rate. From initial Bayesian learning in automatic digital computer to present day Artificial Neural Network (ANN) with Computer Vision, Computer Aided Diagnosis (CAD) is progressing at a very fast scale.

Reference and Bibliography

[1]. Ben-Bassat, Moshe and Lipnick, Edward. Diagnosis and Treatment in MEDAS (Medical Emergency Decisions and Assistance System). Association for Computing Machinery (1977) at https://doi.org/10.1145/800179.810188

[2]. Yarnall, Stephen R. and Kronmal, Richard A. Computer Aids to Medical Diagnosis—Problems and Progress. Association for Computing Machinery (1966) at https://doi.org/10.1145/800256.810706

[3]. Tarnawski, Wojciech and Fraczek, Marcin and Krecicki, Tomasz and Jelen, Michal. Fuzzy Rule-Based Classification System for Computer-Aided Diagnosis in Contact Endoscopy Imaging. Association for Computing Machinery (2008) at https://doi.org/10.1145/1456223.1456317

[4]. Crumb, C. B. and Rupe, C. E. The Automatic Digital Computer as an Aid in Medical Diagnosis. Association for Computing Machinery (1959) at https://doi.org/10.1145/1460299.1460319

[5]. Dwyer, S. J. and Harlow, C. A. and Ausherman, D. A. and Lodwick, G. S. Computer Diagnosis of Radiographic Images. Association for Computing Machinery (1971) at https://doi.org/10.1145/1478873.1479009

[6]. Farooq, Faisal and Krishnapuram, Balaji and Rosales, Romer and Yu, Shipeng and Shavlik, Jude and Kucherlapati, Raju. Predictive Models in Personalized Medicine: Neural Information Processing Systems (NIPS), 2010 Workshop Report. Association for Computing Machinery at https://doi.org/10.1145/1971706.1971714

[7]. Lu, Le and Liu, Meizhu and Ye, Xiaojing and Yu, Shipeng and Huang, Heng. Coarse-to-Fine Classification via Parametric and Nonparametric Models for Computer-Aided Diagnosis. Association for Computing Machinery (2011) at https://doi.org/10.1145/2063576.2064004

[8]. Riegler, Michael and Pogorelov, Konstantin and Markussen, Jonas and Lux, Mathias and Stensland, H\r{a}kon Kvale and de Lange, Thomas and Griwodz, Carsten and Halvorsen, P\r{a}l and Johansen, Dag and Schmidt, Peter T. and Eskeland, Sigrun L. Computer Aided Disease Detection System for Gastrointestinal Examinations. Association for Computing Machinery (2016) at https://doi.org/10.1145/2910017.2910629

[9]. Rodr\'{\i}guez, Jorge Hern\'{a}ndez and Fraile, Francisco Javier Cabrero and Conde, Mar\'{\i}a Jos\'{e} Rodr\'{\i}guez and Llorente, Pablo Luis G\'{o}mez. Computer Aided Detection and Diagnosis in Medical Imaging: A Review of Clinical and Educational Applications. Association for Computing Machinery (2016) at https://doi.org/10.1145/3012430.3012567

[10]. Rodr\'{\i}guez, Jorge Hern\'{a}ndez and Conde, Mar\'{\i}a Jos\'{e} Rodr\'{\i}guez and Fraile, Francisco Javier Cabrero. Artificial Neural Networks Applications in Computer Aided Diagnosis: System Design and Use as an Educational Tool. Association for Computing Machinery (2016) at https://doi.org/10.1145/3012430.3012670

[11]. Wang, Shuai and Cong, Yang and Fan, Huijie and Fan, Baojie and Liu, Lianqing and Yang, Yunsheng and Tang, Yandong and Zhao, Huaici and Yu, Haibin. Multi-Class Latent Concept Pooling for Computer-Aided Endoscopy Diagnosis. Association for Computing Machinery (2017) at https://doi.org/10.1145/3051481

[12]. Riegler, Michael and Pogorelov, Konstantin and Eskeland, Sigrun Losada and Schmidt, Peter Thelin and Albisser, Zeno and Johansen, Dag and Griwodz, Carsten and Halvorsen, P\r{a}l and Lange, Thomas De. From Annotation to Computer-Aided Diagnosis: Detailed Evaluation of a Medical Multimedia System. Association for Computing Machinery (2017) at https://doi.org/10.1145/3079765

[13]. Pack, Chulwoo and Son, Seong-Ho and Shin, Sung. Computer Aided Diagnosis with Boosted Learning for Anomaly Detection in Microwave Tomography. Association for Computing Machinery (2017) at https://doi.org/10.1145/3161534.3161538

[14]. Nagao, Mitsuaki and Lu, Huimin and Kim, Hyoungseop and Aoki, Takatoshi and Kido, Shoji. Detection of Abnormal Regions on Temporal Subtraction Images Based on CNN. Association for Computing Machinery (2019) at https://doi.org/10.1145/3354031.3354049

[15]. Essaf, Firdaous and Li, Yujian and Sakho, Seybou and Kiki, Mesmin J. Mbyamm. Review on Deep Learning Methods Used for Computer-Aided Lung Cancer Detection and Diagnosis. Association for Computing Machinery at https://doi.org/10.1145/3377713.3377732

[16]. Ichikawa, Hirohisa and Goto, Mika. Practical Application and Challenges of Computer-Aided Diagnosis System Using Deep Learning: A Case Study of Gastric Cancer in Japan. Association for Computing Machinery (2022) at https://doi.org/10.1145/3502871.3502883

[17]. Kong, Lingzhi and Ren, Zhiyuan and Zhou, Yan and Ding, Wei and Cheng, Jinyong. Research on Medical Image Classification Based on Image Segmentation and Feature Fusion. Association for Computing Machinery (2022) at https://doi.org/10.1145/3546000.3546023

[18]. Wijegunathileke, Ayeshmantha and Aponso, Achala. AutoMID : A Novel Framework For Automated Computer Aided Diagnosis Of Medical Images. Association for Computing Machinery (2023) at https://doi.org/10.1145/3571560.3571571

[19]. Zhang, Baoming and Yue, Weili and Liu, Qiang and Hu, Shimin. Application of Artificial Intelligence in Medical Imaging Diagnosis. Association for Computing Machinery at https://doi.org/10.1145/3448748.3448810